



Ministry of  
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## **FOUNDATION DESIGN SECTION**

**foundation  
investigation and  
design report**

ENGINEERING MATERIALS OFFICE  
FOUNDATION DESIGN SECTION

WO 14-70016

DIST 14

HWY Local Road

STR SITE 47-191

Wabi Creek Bridge Replacement

DISTRIBUTION

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Foundation Investigation Report  
For  
Wabi Creek Bridge Replacement  
Local Road - Concession IV Henwood  
W.O. 14-70016, Site 47-191  
District #14 (New Liskeard)

**INTRODUCTION**

This report contains the results of a foundation investigation carried out at the above-mentioned site. The fieldwork consisted of two sampled boreholes accompanied with Dynamic Cone Penetration Tests, during the period of 86 08 11 to 86 08 14. The borings were advanced by a continuous flight auger machine mounted on a muskeg vehicle and equipped with 83 mm hollow stem augers.

**SITE DESCRIPTION**

The site is located at the crossing of a local road (Concession IV, Henwood) approx. 70 m west of the first side road west of Hwy. #65.

The terrain surrounding the creek valley is flat to gently rolling farmland. Wabi Creek flows from north to south and it is about 5 m wide and 1.5 m deep at the crossing.

**SUBSURFACE CONDITIONS**

**GENERAL**

Two main deposits were encountered at the borehole locations: Silty Clay and Varved Clay. These strata are separated by a thin layer (0.3-0.5 m) of Silty Sand. No bedrock was encountered within a depth of 36 m below the creek bed. In Borehole #1 which is located on the west approach to the existing structure a 3.2 m thick fill material (silty clay) was encountered.

The boundaries of the deposits, together with the field and laboratory test results are shown on the Record of Borehole Sheets contained in the Appendix of this report. All the elevations quoted in this report are referenced to an assumed benchmark having the following description: 'B.M. #1, El. 100.00, nail in east root of 0.4 jack pine, 23.8 m Lt. of Sta. 0 + 030 .

A description of the different strata encountered is given below.

Silty Clay - Traces of Sand and Gravel  
and Occasional Undecayed Organics

This deposit was encountered immediately below the original ground level or below the fill material to El. 90.9 at both boring locations. The material consists mainly of silty clay having medium plasticity. In addition, traces of sand and gravel and occasionally undecayed organics (wood chips and roots) were also observed.

The natural moisture content varies from 15% to 30%. The consistency ranges from soft to stiff.

Silty Clay - Some Sand, Traces of  
Gravel, Fill Material

This deposit was encountered in B.H. #1 only from ground level (El. 96.1) to El. 92.9. It is believed that this material was taken out from the adjacent road cuts. The basic component is silty clay (Low Plasticity) with some sand and traces of gravel. The consistency is classified as firm to stiff.

Silty Sand - Traces of Clay and Gravel

A thin layer (0.3-0.5 m) of silty sand, containing traces of clay and gravel was intersected at El. 90.9 in both boreholes. Grain-size distribution tests gave the following results: Gravel 0-1%, Sand 76-81%, Silt 14-19% and Clay 5%. The material is estimated to be in a very loose state.

Varved Clay

This is the main deposit at this site and it was encountered below the silty sand layer. The lower boundary was not determined since the sampled boreholes were terminated within this zone at El. 73.8 (B.H.#1) and at El. 77.4 (B.H.#2). However, the dynamic cone penetration tests were advanced to El. 61.7 and El. 57.3 in boreholes No. 1 and No. 2 respectively without reaching refusal. The material consists of layers of silt and clay in random order of occurrence. The thickness of the layers ranges from 5 mm to 150 mm. The field vane test results varied from 20 kPa to 82 kPa. The sensitivity ranges from 2 to 6. In general, the undrained shear strength increases with depth.

The following shear strength values are recommended for stability analyses:

El. 90 - El. 86	21 kPa
El. 86 - El. 83	27 kPa
Below El. 83	60 kPa

The unit weight of the material ranges from 17 kN/m<sup>3</sup> to 18.9 kN/m<sup>3</sup>.

The consistency of the overall deposit is classified as soft to stiff.

#### Groundwater Conditions

The following groundwater levels were observed:

B.H. #1	El. 92.5
B.H. #2	El. 89.7

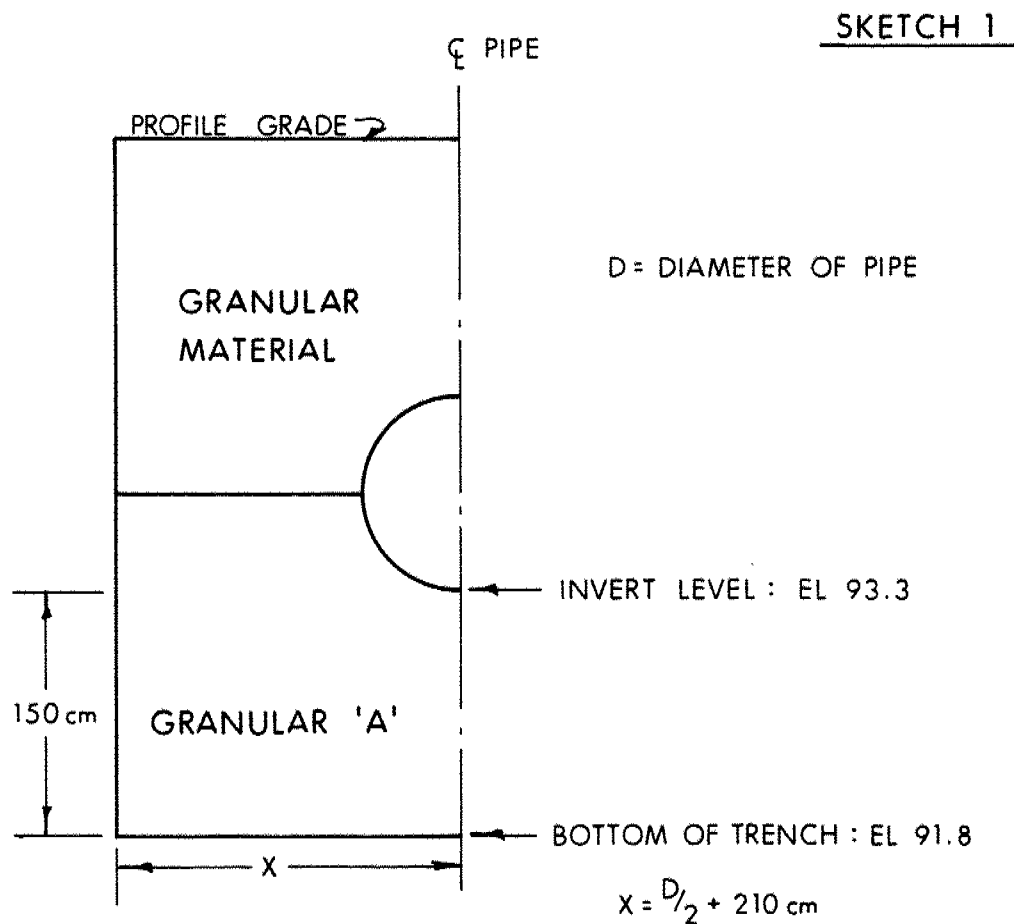
The water level of the creek was at El. 92.7 at the time (Aug. 1986) of the field investigation.

### DISCUSSION AND RECOMMENDATIONS

Presently, an approx. 22 m long single lane, wooden structure crosses Wabi Creek at Sta. 0 + 122. The bridge is supported on timber pile bents. It is proposed to replace the bridge on a slightly shifted alignment (about 2 m to the north) at Sta. 0 + 095 with a CSP Culvert. This proposal requires the diversion of the creek west of the present channel. The following design details were submitted to our office:

- 1) Diameter: 4.0 m
- 2) Skew: 20° (from the north towards the west)
- 3) Invert Level: El. 93.3
- 4) Profile Grade of Municipal Rd.: El. 98.3

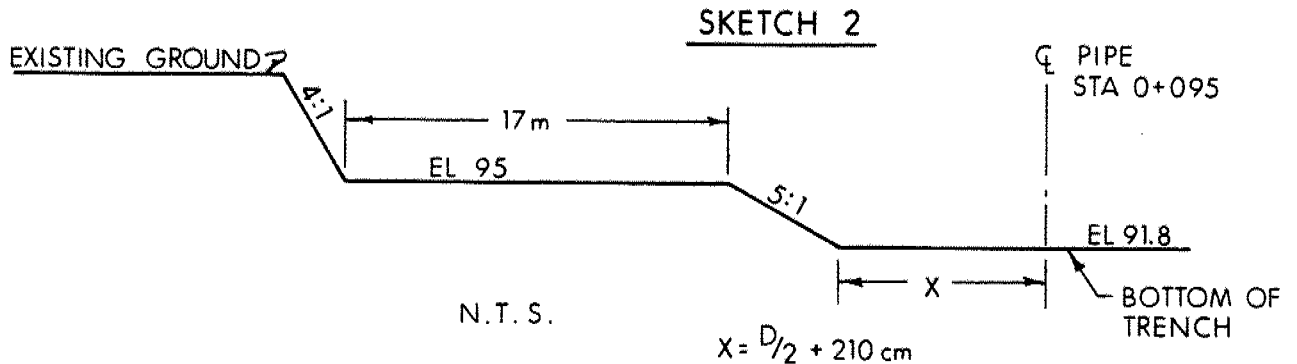
In order to ensure the integrity and the future performance of the proposed culvert, it is recommended that the pertinent M.T.C. specifications and standards be followed. The bedding for this type of pipe is outlined on Standard DD-808A, Type 4 (Rev. 6, 1984 08 01). The minimum requirements are as illustrated on the following sketch.



N.T.S.

The frost protection requirements in this area is a minimum of 2.1 m of cover.

In order to place the culvert as required, excavation of the existing fill and the original subsoil will be required. To ensure the stability of the natural banks of the creek, stability analyses were carried out. The obtained results have suggested the following geometry for the duration of the installation.



This excavation should be carried out along the entire length of the pipe.

In addition, 9 m long, half height berms are required in the transverse direction. Thus the total length of the pipe will be approx. 50 m.

All the excavated material should be transported away from the site and must not be stockpiled even temporarily on the edge of excavations.

Taking into consideration all of these factors, it is our opinion that this scheme is very costly and impractical. Therefore, we are recommending that the existing wooden bridge be replaced with a structure having concrete deck and supported on No. 36 treated timber piles. The piles should be driven to the elevation necessary to achieve the required capacity.

In determining the safe capacity of a No. 36 timber pile, the following equation may be used:

$$Q = 9.58 L \text{ (KN)}$$

where

Q = Safe Capacity of one pile

L = Embedded length in original ground (in meters)

For the purposes of the O.H.B.D.C., assuming 12 m embedded length, the following values are recommended:

Factored Capacity at U.L.S.: 190 kN

Capacity at S.L.S. Type II: 115 kN

The pile caps should have a minimum of 2.1 m of earth cover for frost protection.

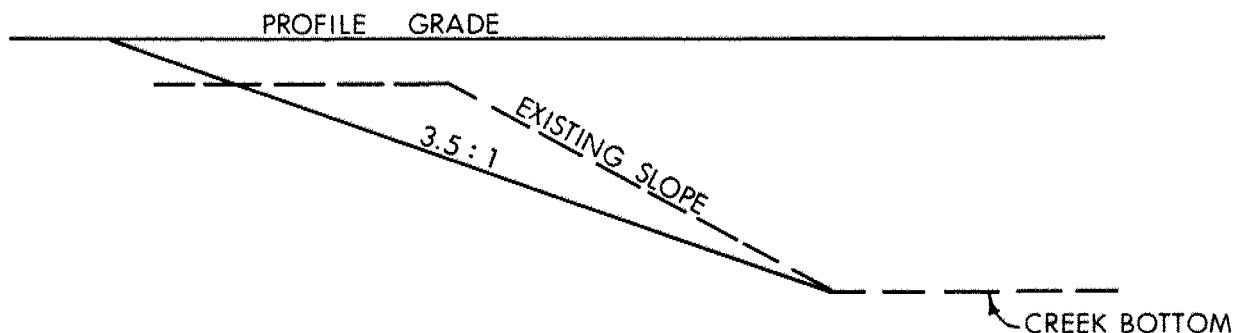
Earth pressures should be computed as per Subsection 6.6.1.2.2 of the Code. A yielding foundation condition may be assumed. The Granular 'A' or 'B' backfill should be in accordance with Special Provision No. 121 (dated October, 1983). The following parameters are recommended for the granular backfill:

	Gran. 'A'	Gran. 'B'
Angle of Internal Friction:	$\phi = 35^\circ$	$30^\circ$
Unit Weight ( $\text{kN/m}^3$ )	$\gamma = 22.8$	21.2

The length of the new structure will be of course dependent on the height and dimensions of the forward slopes of the approaches.

It is recommended that the forward slopes should not be steeper than 3.5 H to 1 V as illustrated on Sketch #3.

### SKETCH 3



N.T.S.



Should approach fills be constructed half height berms will be required if the effective height (distance between profile grade and creek bed) is over a certain magnitude as tabulated below:

<u>Effective Height (m)</u>	<u>Berm Length (m)</u>
5	0
6	6
8	17

The slopes of the core and berm should not be steeper than 2H:1V.

Erosion protection should be provided.

#### MISCELLANEOUS

The fieldwork for the project was supervised by Mr. P. Lough, Engineering Student. The equipment used was owned and operated by Master Soil Investigation Ltd. This report was prepared by Mr. P. Payer and reviewed by Mr. K.G. Selby.



P. Payer, P. Eng.  
Senior Foundations Engineer



K.G. Selby, P. Eng.  
Chief Foundations Engineer  
(West)

## APPENDIX

## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND/OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

	SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING		VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING		VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

S S	SPLIT SPOON	T P	THINWALL PISTON
W S	WASH SAMPLE	O S	OSTERBERG SAMPLE
S T	SLOTTED TUBE SAMPLE	R C	ROCK CORE
B S	BLOCK SAMPLE	P H	T W ADVANCED HYDRAULICALLY
C S	CHUNK SAMPLE	P M	T W ADVANCED MANUALLY
T W	THINWALL OPEN	F S	FOIL SAMPLE

### MECHANICAL PROPERTIES OF SOIL

$m_v$	$\text{kPa}^{-1}$	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_a$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	$\text{m}^2/\text{s}$	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### PHYSICAL PROPERTIES OF SOIL

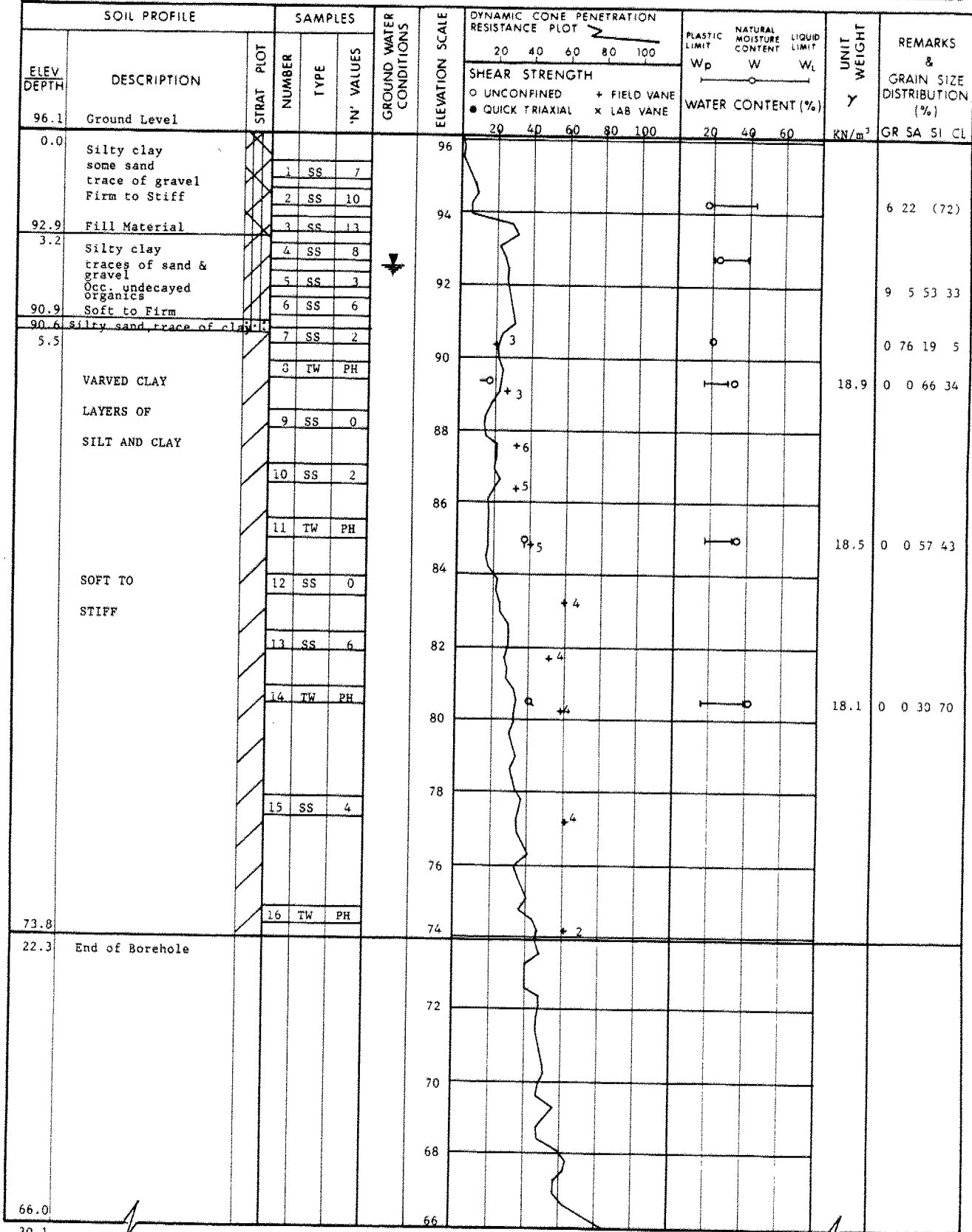
$\rho_s$	$\text{kg}/\text{m}^3$	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{\min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{\max} - e}{e_{\max} - e_{\min}}$
$\rho_w$	$\text{kg}/\text{m}^3$	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	$\text{kg}/\text{m}^3$	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	$\text{kg}/\text{m}^3$	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	$\text{m}^3/\text{s}$	RATE OF DISCHARGE
$\gamma_d$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{\text{sat}}$	$\text{kg}/\text{m}^3$	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{\text{sat}}$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	$\text{kg}/\text{m}^3$	DENSITY OF SUBMERGED SOIL	$e_{\max}$	1, %	VOID RATIO IN LOOSEST STATE	j	$\text{KN}/\text{m}^2$	SEEPAGE FORCE
$\gamma'$	$\text{KN}/\text{m}^3$	UNIT WEIGHT OF SUBMERGED SOIL						

# RECORD OF BOREHOLE No 1

METRIC

WO 14-70016 LOCATION Sta. 0 + 94.0 ; O/S 2.5 m LT 6  
DIST 14 HWY LOCAL BOREHOLE TYPE Continuous Flight Auger (H.S.)  
DATUM Assumed DATE 86-08-11  
ORIGINATED BY P.L.  
COMPILED BY P.L.  
CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION



Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

Continued

# RECORD OF BOREHOLE No 1 Cont'd

METRIC

WO 14-70016 LOCATION Sta. 0 + 94.0 O/S 2.5 m LT 5 ORIGINATED BY P.L.  
 DIST 14 HWY LOCAL BOREHOLE TYPE Continuous Flight Auger COMPILED BY P.L.  
 DATUM Geodetic DATE 86-08-11 CHECKED BY \_\_\_\_\_

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20					
66.0 30.1	Continued												
61.7 34.4	End of Cone Test												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

# RECORD OF BOREHOLE No 2

METRIC

WO 14-70016 LOCATION Sta. 0 + 101.4 O/S 18.0 m RT 6  
DIST 14 HWY LOCAL BOREHOLE TYPE Continuous Flight Auger (H.S.)  
DATUM Assumed DATE 86-08-13  
ORIGINATED BY P.L.  
COMPILED BY P.L.  
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ KN/m <sup>3</sup>	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			SHEAR STRENGTH						
93.6	Ground Level							20 40 60 80 100						
0.0	Silty clay Some sand Occ. undecayed organics Soft to Stiff		1	SS	0									0 39 44 17
90.9			2	SS	4									1 81 14 3 0 2 65 33
90.4	silty sand, traces of clay and gravel		3	SS	2									
3.2			4	SS	1									
	Varved Clay		5	SS	1									
	Layers of Silt and Clay		6	TW	PH								18.7	0 0 72 28
			7	SS	0									
	SOFT TO STIFF		8	SS	0									
			9	TW	PM								17	0 0 27 73
			10	SS	1									
			11	SS	1									
			12	TW	PH									
77.4			13	SS	4									
16.2	End of Borehole													
63.5														

OFFICE REPORT ON SOIL EXPLORATION

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

Continued

# RECORD OF BOREHOLE No 2 Cont'd METRIC

WO 14-70016 LOCATION Sta. 0 + 101.4 O/S 18.0 m RT 6  
 DIST 14 HWY LOCAL BOREHOLE TYPE Continuous Flight Auger (#5) ORIGINATED BY P.L.  
 DATUM Assumed DATE 86-08-13 COMPILED BY P.L.  
 CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
63.5	Continued												
30.1													
57.3													
36.3	End of Cone												

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to  
Sensitivity

20  
15 5 (%) STRAIN AT FAILURE  
10

**METRIC**  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN KILOMETRES + METRES.

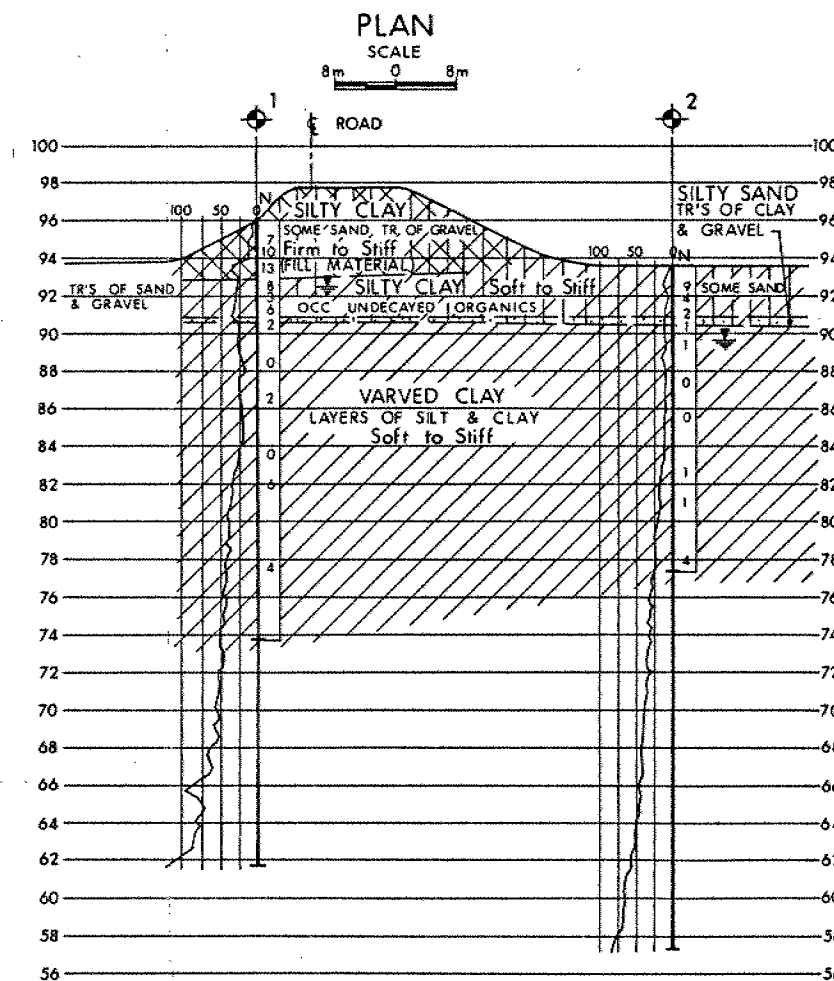
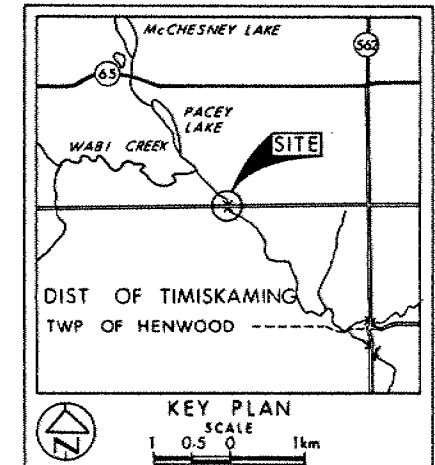
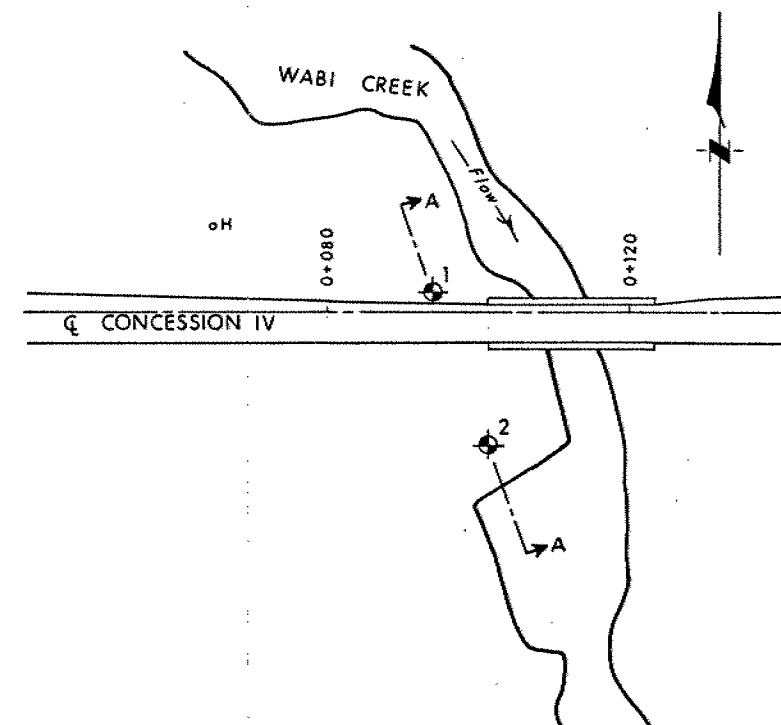
CONT No  
WO No 14-70016



WABI CREEK

SHEET

BORE HOLE LOCATIONS & SOIL STRATA



SECTION A-A

SCALE  
4m 2 0 4m

LEGEND

- ◆ Bore Hole
- ⊕ Dynamic Cone Penetration Test (Cone)
- ⊕ Bore Hole & Cone
- N Blows/0.3m (Std Pen Test, 475 J/blow)
- CONE Blows/0.3m (60° Cone, 475 J/blow)
- W L at time of investigation 86 08

No	ELEVATION	STATION	OFFSET
1	96.1	0+94.0	2.5m Lt
2	93.6	0+101.4	18.0m Rt

NOTE

The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION

Geocres No 31M-51

HWY No	CONCESSION IV	HENWOOD	DIST 14
SUBAMD PP	CHECKED	DATE 87 06 08	SITE 47-191
DRAWN DT	CHECKED	APPROVED	DWG 1470016-A



GEOCRETS No. 31M-51DIST. 14 REGION                     W.P. No.                     CONT. No.                     W. O. No. 93-11014STR. SITE No. 47-204HWY. No. MunicipalLOCATION Twop of Kerns; lot 2,  
Conc. III & IVNo of PAGES -                     

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OVERSIZE DRAWINGS TO BE INCLUDED WITH THIS REPORT.                     REMARKS:



Ministry of  
Transportation and  
Communications

P. PAYER

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The terrain surrounding the creek valley is flat to gently rolling farmland. Wabi Creek flows from north to south and it is about 5 m wide and 1.5 m deep at the crossing.

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A thin layer (0.3-0.5 m) of silty sand, containing traces of clay and gravel was intersected at El. 90.9 in both boreholes. Grain-size distribution tests gave the following results: Gravel 0-1%, Sand 76-81%, Silt 14-19% and Clay 5%. The material is estimated to be in a very loose state.

Varved Clay

This is the main deposit at this site and it was encountered below the silty sand layer. The lower boundary was not determined since the sampled boreholes were terminated within this zone at El. 73.8 (B.H.#1) and at El. 77.4 (B.H.#2). However, the dynamic cone penetration tests were advanced to El. 61.7 and El. 57.3 in boreholes No. 1 and No. 2 respectively without reaching refusal. The material consists of layers of silt and clay in random order of occurrence. The thickness of the layers ranges from 5 mm to 150 mm. The field vane test results varied from 20 kPa to 82 kPa. The sensitivity ranges from 2 to 6. In general, the undrained shear strength increases with depth.

The following shear strength values are recommended for stability analyses:

El. 90 - El. 86	21 kPa
El. 86 - El. 83	27 kPa
Below El. 83	60 kPa

The unit weight of the material ranges from 17 kN/m<sup>3</sup> to 18.9 kN/m<sup>3</sup>.

The consistency of the overall deposit is classified as soft to stiff.

#### Groundwater Conditions

The following groundwater levels were observed:

B.H. #1	El. 92.5
B.H. #2	El. 89.7

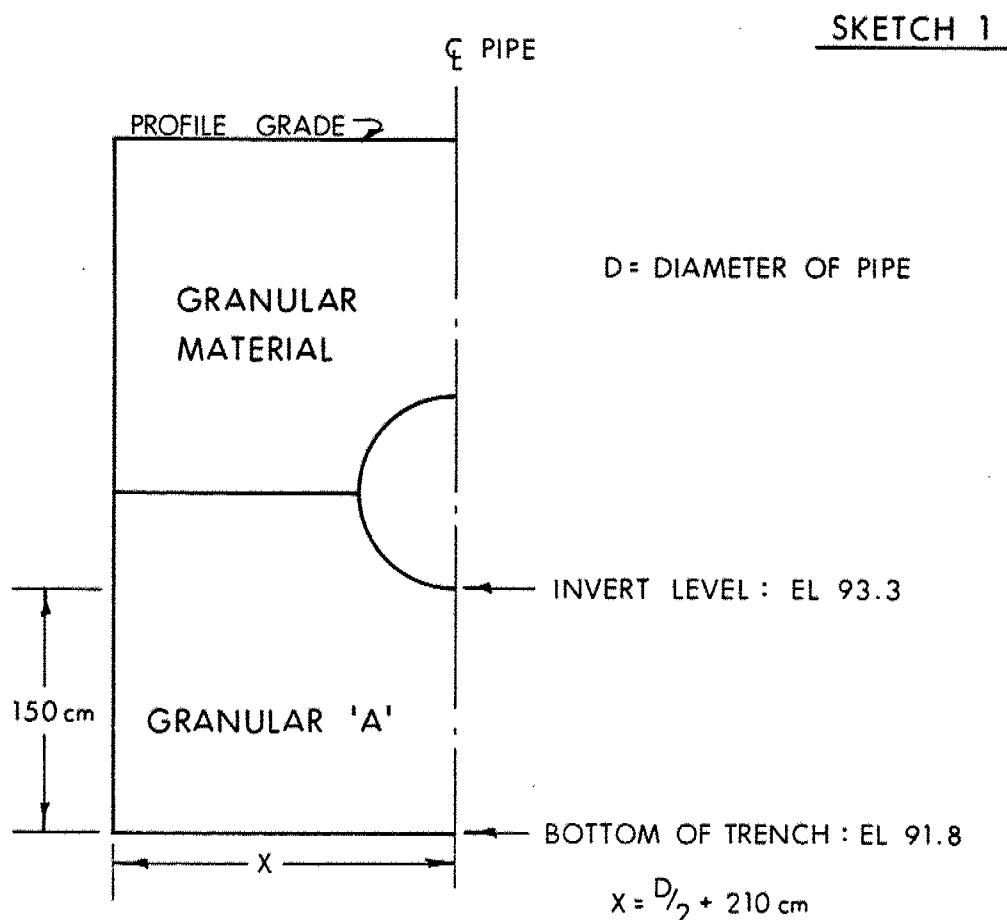
The water level of the creek was at El. 92.7 at the time (Aug. 1986) of the field investigation.

### DISCUSSION AND RECOMMENDATIONS

Presently, an approx. 22 m long single lane, wooden structure crosses Wabi Creek at Sta. 0 + 122. The bridge is supported on timber pile bents. It is proposed to replace the bridge on a slightly shifted alignment (about 2 m to the north) at Sta. 0 + 095 with a CSP Culvert. This proposal requires the diversion of the creek west of the present channel. The following design details were submitted to our office:

- 1) Diameter: 4.0 m
- 2) Skew: 20° (from the north towards the west)
- 3) Invert Level: El. 93.3
- 4) Profile Grade of Municipal Rd.: El. 98.3

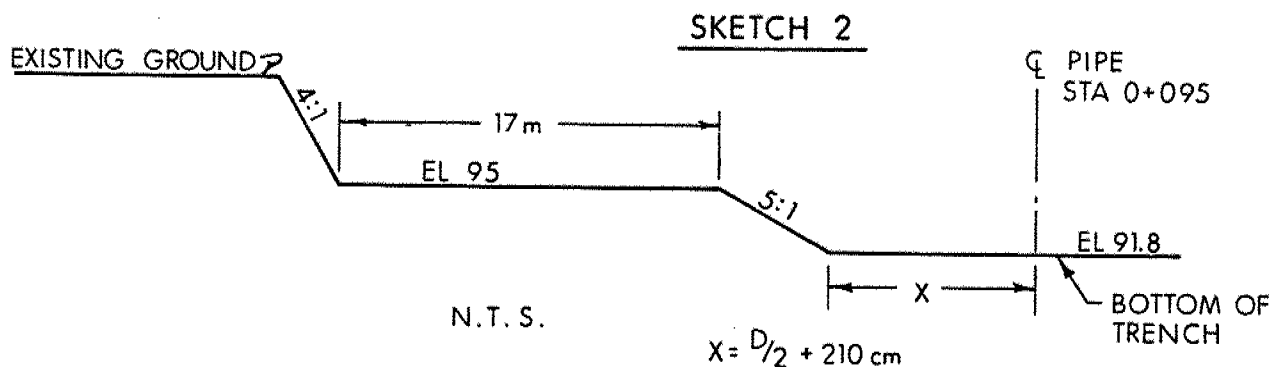
In order to ensure the integrity and the future performance of the proposed culvert, it is recommended that the pertinent M.T.C. specifications and standards be followed. The bedding for this type of pipe is outlined on Standard DD-808A, Type 4 (Rev. 6, 1984 08 01). The minimum requirements are as illustrated on the following sketch.



N.T.S.

The frost protection requirements in this area is a minimum of 2.1 m of cover.

In order to place the culvert as required, excavation of the existing fill and the original subsoil will be required. To ensure the stability of the natural banks of the creek, stability analyses were carried out. The obtained results have suggested the following geometry for the duration of the installation.



This excavation should be carried out along the entire length of the pipe.

In addition, 9 m long, half height berms are required in the transverse direction. Thus the total length of the pipe will be approx. 50 m.

All the excavated material should be transported away from the site and must not be stockpiled even temporarily on the edge of excavations.

Taking into consideration all of these factors, it is our opinion that this scheme is very costly and impractical. Therefore, we are recommending that the existing wooden bridge be replaced with a structure having concrete deck and supported on No. 36 treated timber piles. The piles should be driven to the elevation necessary to achieve the required capacity.

In determining the safe capacity of a No. 36 timber pile, the following equation may be used:

$$Q = 9.58 L \text{ (KN)}$$

where

Q = Safe Capacity of one pile

L = Embedded length in original ground (in meters)



For the purposes of the O.H.B.D.C., assuming 12 m embedded length, the following values are recommended:

Factored Capacity at U.L.S.: 190 kN

Capacity at S.L.S. Type II: 115 kN

The pile caps should have a minimum of 2.1 m of earth cover for frost protection.

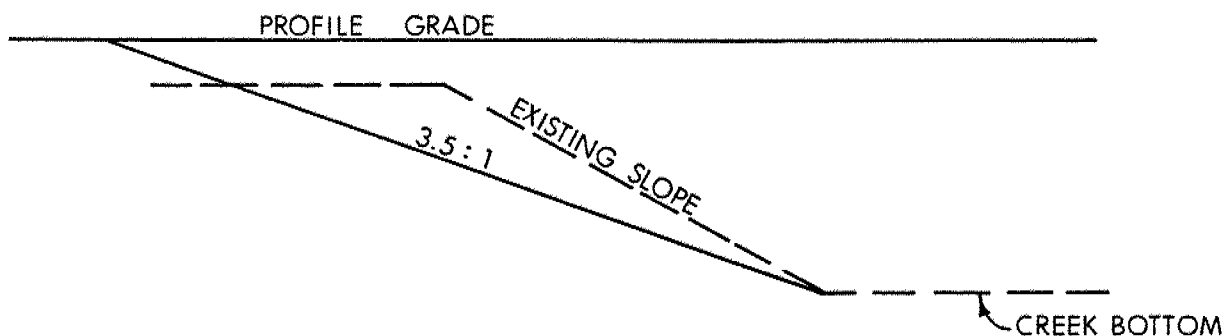
Earth pressures should be computed as per Subsection 6.6.1.2.2 of the Code. A yielding foundation condition may be assumed. The Granular 'A' or 'B' backfill should be in accordance with Special Provision No. 121 (dated October, 1983). The following parameters are recommended for the granular backfill:

	Gran. 'A'	Gran. 'B'
Angle of Internal Friction: $\phi =$	$35^{\circ}$	$30^{\circ}$
Unit Weight ( $\text{kN/m}^3$ ) $\gamma =$	22.8	21.2

The length of the new structure will be of course dependent on the height and dimensions of the forward slopes of the approaches.

It is recommended that the forward slopes should not be steeper than 3.5 H to 1 V as illustrated on Sketch #3.

### SKETCH 3



N.T.S.

Should approach fills be constructed half height berms will be required if the effective height (distance between profile grade and creek bed) is over a certain magnitude as tabulated below:

<u>Effective Height (m)</u>	<u>Berm Length (m)</u>
5	0
6	6
8	17

The slopes of the core and berm should not be steeper than 2H:1V.

Erosion protection should be provided.

#### MISCELLANEOUS

The fieldwork for the project was supervised by Mr. P. Lough, Engineering Student. The equipment used was owned and operated by Master Soil Investigation Ltd. This report was prepared by Mr. P. Payer and reviewed by Mr. K.G. Selby.



P. Payer, P. Eng.  
Senior Foundations Engineer



K.G. Selby, P. Eng.  
Chief Foundations Engineer  
(West)

## APPENDIX

## EXPLANATION OF TERMS USED IN REPORT

**N VALUE:** THE STANDARD PENETRATION TEST (SPT) N VALUE IS THE NUMBER OF BLOWS REQUIRED TO CAUSE A STANDARD 51mm O.D. SPLIT BARREL SAMPLER TO PENETRATE 0.3m INTO UNDISTURBED GROUND IN A BOREHOLE WHEN DRIVEN BY A HAMMER WITH A MASS OF 63.5kg, FALLING FREELY A DISTANCE OF 0.76m. FOR PENETRATIONS OF LESS THAN 0.3m N VALUES ARE INDICATED AS THE NUMBER OF BLOWS FOR THE PENETRATION ACHIEVED. AVERAGE N VALUE IS DENOTED THUS  $\bar{N}$ .

**DYNAMIC CONE PENETRATION TEST:** CONTINUOUS PENETRATION OF A CONICAL STEEL POINT (51mm O.D. 60° CONE ANGLE) DRIVEN BY 475 J IMPACT ENERGY ON 'A' SIZE DRILL RODS. THE RESISTANCE TO CONE PENETRATION IS MEASURED AS THE NUMBER OF BLOWS FOR EACH 0.3m ADVANCE OF THE CONICAL POINT INTO THE UNDISTURBED GROUND.

SOILS ARE DESCRIBED BY THEIR COMPOSITION AND CONSISTENCY OR DENSENESS.

**CONSISTENCY:** COHESIVE SOILS ARE DESCRIBED ON THE BASIS OF THEIR UNDRAINED SHEAR STRENGTH ( $c_u$ ) AS FOLLOWS:

$c_u$ (kPa)	0 - 12	12 - 25	25 - 50	50 - 100	100 - 200	> 200
	VERY SOFT	SOFT	FIRM	STIFF	VERY STIFF	HARD

**DENSENESS:** COHESIONLESS SOILS ARE DESCRIBED ON THE BASIS OF DENSENESS AS INDICATED BY SPT N VALUES AS FOLLOWS:

N (BLOWS/0.3m)	0 - 5	5 - 10	10 - 30	30 - 50	> 50
	VERY LOOSE	LOOSE	COMPACT	DENSE	VERY DENSE

ROCKS ARE DESCRIBED BY THEIR COMPOSITION AND STRUCTURAL FEATURES AND / OR STRENGTH.

**RECOVERY:** SUM OF ALL RECOVERED ROCK CORE PIECES FROM A CORING RUN EXPRESSED AS A PERCENT OF THE TOTAL LENGTH OF THE CORING RUN.

**MODIFIED RECOVERY:** SUM OF THOSE INTACT CORE PIECES, 100mm+ IN LENGTH EXPRESSED AS A PERCENT OF THE LENGTH OF THE CORING RUN. THE ROCK QUALITY DESIGNATION (RQD), FOR MODIFIED RECOVERY, IS:

RQD (%)	0 - 25	25 - 50	50 - 75	75 - 90	90 - 100
	VERY POOR	POOR	FAIR	GOOD	EXCELLENT

**JOINTING AND BEDDING:**

SPACING	50mm	50 - 300mm	0.3m - 1m	1m - 3m	> 3m
JOINTING	VERY CLOSE	CLOSE	MOD. CLOSE	WIDE	VERY WIDE
BEDDING	VERY THIN	THIN	MEDIUM	THICK	VERY THICK

## ABBREVIATIONS AND SYMBOLS

### FIELD SAMPLING

SS	SPLIT SPOON	TP	THINWALL PISTON
WS	WASH SAMPLE	OS	OSTERBERG SAMPLE
ST	SLOTTED TUBE SAMPLE	RC	ROCK CORE
BS	BLOCK SAMPLE	PH	TW ADVANCED HYDRAULICALLY
CS	CHUNK SAMPLE	PM	TW ADVANCED MANUALLY
TW	THINWALL OPEN	FS	FOIL SAMPLE

### STRESS AND STRAIN

$u_w$	kPa	PORE WATER PRESSURE
$r_u$	1	PORE PRESSURE RATIO
$\sigma$	kPa	TOTAL NORMAL STRESS
$\sigma'$	kPa	EFFECTIVE NORMAL STRESS
$\tau$	kPa	SHEAR STRESS
$\sigma_1, \sigma_2, \sigma_3$	kPa	PRINCIPAL STRESSES
$\epsilon$	%	LINEAR STRAIN
$\epsilon_1, \epsilon_2, \epsilon_3$	%	PRINCIPAL STRAINS
E	kPa	MODULUS OF LINEAR DEFORMATION
G	kPa	MODULUS OF SHEAR DEFORMATION
$\mu$	1	COEFFICIENT OF FRICTION

### MECHANICAL PROPERTIES OF SOIL

$m_v$	kPa <sup>-1</sup>	COEFFICIENT OF VOLUME CHANGE
$C_c$	1	COMPRESSION INDEX
$C_s$	1	SWELLING INDEX
$C_\alpha$	1	RATE OF SECONDARY CONSOLIDATION
$c_v$	m <sup>2</sup> /s	COEFFICIENT OF CONSOLIDATION
H	m	DRAINAGE PATH
$T_v$	1	TIME FACTOR
U	%	DEGREE OF CONSOLIDATION
$\sigma'_{vo}$	kPa	EFFECTIVE OVERBURDEN PRESSURE
$\sigma'_p$	kPa	PRECONSOLIDATION PRESSURE
$\tau_f$	kPa	SHEAR STRENGTH
$c'$	kPa	EFFECTIVE COHESION INTERCEPT
$\phi'$	-°	EFFECTIVE ANGLE OF INTERNAL FRICTION
$c_u$	kPa	APPARENT COHESION INTERCEPT
$\phi_u$	-°	APPARENT ANGLE OF INTERNAL FRICTION
$\tau_R$	kPa	RESIDUAL SHEAR STRENGTH
$\tau_r$	kPa	REMOULDED SHEAR STRENGTH
$S_t$	1	SENSITIVITY = $\frac{c_u}{\tau_r}$

### PHYSICAL PROPERTIES OF SOIL

$\rho_s$	kg/m <sup>3</sup>	DENSITY OF SOLID PARTICLES	e	1, %	VOID RATIO	$e_{min}$	1, %	VOID RATIO IN DENSEST STATE
$\gamma_s$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOLID PARTICLES	n	1, %	POROSITY	$I_D$	1	DENSITY INDEX = $\frac{e_{max} - e}{e_{max} - e_{min}}$
$\rho_w$	kg/m <sup>3</sup>	DENSITY OF WATER	w	1, %	WATER CONTENT	D	mm	GRAIN DIAMETER
$\gamma_w$	kN/m <sup>3</sup>	UNIT WEIGHT OF WATER	$S_r$	%	DEGREE OF SATURATION	$D_n$	mm	n PERCENT - DIAMETER
$\rho$	kg/m <sup>3</sup>	DENSITY OF SOIL	$w_L$	%	LIQUID LIMIT	$C_u$	1	UNIFORMITY COEFFICIENT
$\gamma$	kN/m <sup>3</sup>	UNIT WEIGHT OF SOIL	$w_p$	%	PLASTIC LIMIT	h	m	HYDRAULIC HEAD OR POTENTIAL
$\rho_d$	kg/m <sup>3</sup>	DENSITY OF DRY SOIL	$w_s$	%	SHRINKAGE LIMIT	q	m <sup>3</sup> /s	RATE OF DISCHARGE
$\gamma_d$	kN/m <sup>3</sup>	UNIT WEIGHT OF DRY SOIL	$I_p$	%	PLASTICITY INDEX = $w_L - w_p$	v	m/s	DISCHARGE VELOCITY
$\rho_{sat}$	kg/m <sup>3</sup>	DENSITY OF SATURATED SOIL	$I_L$	1	LIQUIDITY INDEX = $\frac{w - w_p}{I_p}$	i	1	HYDRAULIC GRADIENT
$\gamma_{sat}$	kN/m <sup>3</sup>	UNIT WEIGHT OF SATURATED SOIL	$I_C$	1	CONSISTENCY INDEX = $\frac{w_L - w}{I_p}$	k	m/s	HYDRAULIC CONDUCTIVITY
$\rho'$	kg/m <sup>3</sup>	DENSITY OF SUBMERGED SOIL	$e_{max}$	1, %	VOID RATIO IN LOOSEST STATE	j	kN/m <sup>3</sup>	SEEPAGE FORCE
$\gamma'$	kN/m <sup>3</sup>	UNIT WEIGHT OF SUBMERGED SOIL						

# RECORD OF BOREHOLE No 1

METRIC

WO 14-70016 LOCATION Sta. 0 + 94.0 ; O/S 2.5 m LT 6  
DIST 14 HWY LOCAL BOREHOLE TYPE Continuous Flight Auger (H.S.)  
DATUM Assumed DATE 86-08-11  
ORIGINATED BY P.L.  
COMPILED BY P.L.  
CHECKED BY

OFFICE REPORT ON SOIL EXPLORATION

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT		PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV. DEPTH	DESCRIPTION	STRAT. PLOT	NUMBER	TYPE			'N' VALUES	20 40 60 80 100					
96.1	Ground Level												
0.0	Silty clay some sand trace of gravel Firm to Stiff		1	SS	7								
			2	SS	10								
92.9	Fill Material		3	SS	13								
3.2	Silty clay traces of sand & gravel Occ. undecayed organics Soft to Firm		4	SS	8								
			5	SS	3								
90.9	Soft to Firm		6	SS	6								
90.6	Silty sand, trace of clay		7	SS	2								
5.5	VARVED CLAY  LAYERS OF  SILT AND CLAY   SOFT TO  STIFF		8	TW	PH								
			9	SS	0								
			10	SS	2								
			11	TW	PH								
			12	SS	0								
			13	SS	6								
			14	TW	PH								
			15	SS	4								
			16	TW	PH								
73.8	End of Borehole												
22.3													
66.0													
30.1													

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

Continued

# RECORD OF BOREHOLE No 1 Cont'd

METRIC

WO 14-70016 LOCATION Sta. 0 + 94.0 O/S 2.5 m LT G  
DIST 14 HWY LOCAL BOREHOLE TYPE Continuous Flight Auger  
DATUM Geodetic DATE 86-08-11  
ORIGINATED BY P.L.  
COMPILED BY P.L.  
CHECKED BY

SOIL PROFILE		SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT					PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%) GR SA SI CL
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE			'N' VALUES	20	40	60	80					
66.0	Continued															
30.1																
61.7																
34.4	End of Cone Test															

OFFICE REPORT ON SOIL EXPLORATION

+3, x5: Numbers refer to Sensitivity  
20  
15 5 (%) STRAIN AT FAILURE  
10

# RECORD OF BOREHOLE No 2

METRIC

WO 14-70016 LOCATION Sta. 0 + 101.4 O/S 18.0 m RT 6  
DIST 14 HWY LOCAL BOREHOLE TYPE Continuous Flight Auger (H.S.)  
DATUM Assumed DATE 86-08-13  
ORIGINATED BY P.L.  
COMPILED BY P.L.  
CHECKED BY

SOIL PROFILE			SAMPLES			GROUND WATER CONDITIONS	ELEVATION SCALE	DYNAMIC CONE PENETRATION RESISTANCE PLOT				PLASTIC LIMIT W <sub>p</sub>	NATURAL MOISTURE CONTENT W	LIQUID LIMIT W <sub>L</sub>	UNIT WEIGHT γ	REMARKS & GRAIN SIZE DISTRIBUTION (%)
ELEV DEPTH	DESCRIPTION	STRAT PLOT	NUMBER	TYPE	'N' VALUES			20	40	60	80	100				
93.6	Ground Level															
0.0	Silty clay Some sand Occ. undecayed organics Soft to Stiff		1	SS	9		92									0 39 44 17
90.9			2	SS	4											1 81 14 5
90.4	Silty sand, traces of clay and gravel		3	SS	2											0 2 65 33
90.4			4	SS	1											
3.2	Varved Clay  Layers of Silt and Clay  SOFT TO STIFF		5	SS	1		90								18.7	0 0 72 28
			6	TW	PH											
			7	SS	0		88									
			8	SS	0		86									
			9	TW	PM		84								17	0 0 27 73
			10	SS	1		82									
			11	SS	1		80									
			12	TW	PH		78									
77.4			13	SS	4											
16.2	End of Borehole															
							76									
							74									
							72									
							70									
							68									
							66									
63.5							64									

OFFICE REPORT ON SOIL EXPLORATION

Continued

+3, x5: Numbers refer to  
Sensitivity

20  
15  
10  
5 (%) STRAIN AT FAILURE

Continued

## RECORD OF BOREHOLE No 2 Cont'd METRIC

WO 14-70016 LOCATION Sta. 0 + 101.4 O/S 18.0 m RT C ORIGINATED BY P.L.  
DIST 14 HWY LOCAL BOREHOLE TYPE Continuous Flight Auger (#5) COMPILED BY P.L.  
DATUM Assumed DATE 86-08-13 CHECKED BY \_\_\_\_\_


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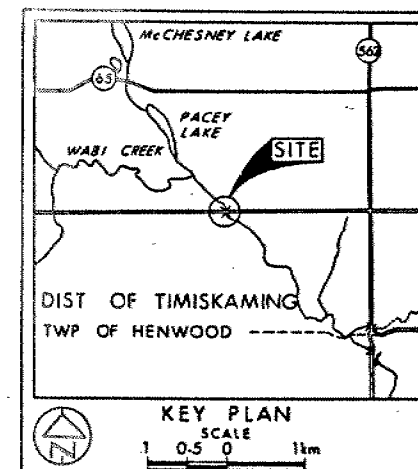
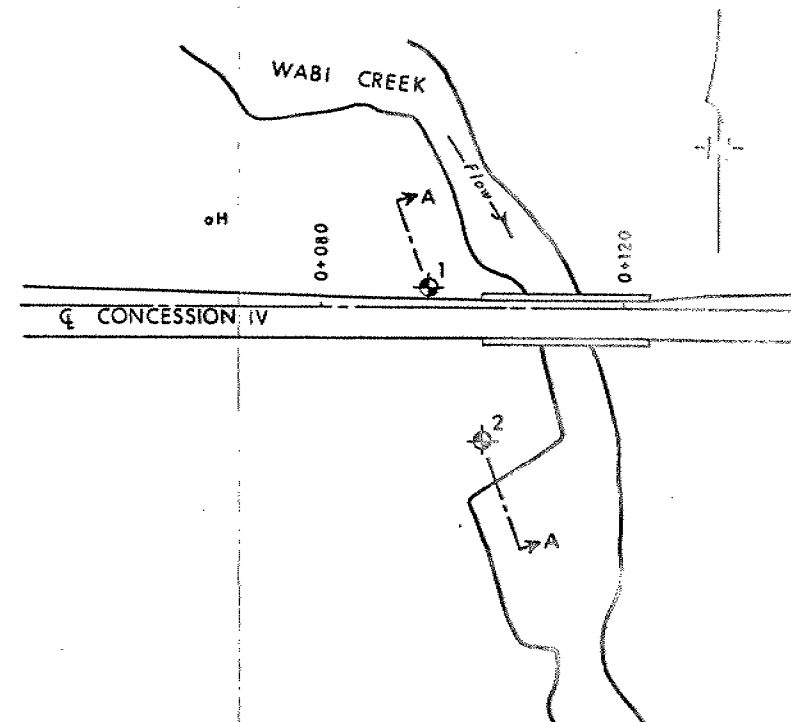
+3, x5: Numbers refer to Sensitivity

OFFICE REPORT ON SOIL EXPLORATION



WETRIC  
DIMENSIONS ARE IN METRES  
AND/OR MILLIMETRES UNLESS  
OTHERWISE SHOWN. STATIONS  
IN METRES & METRES.

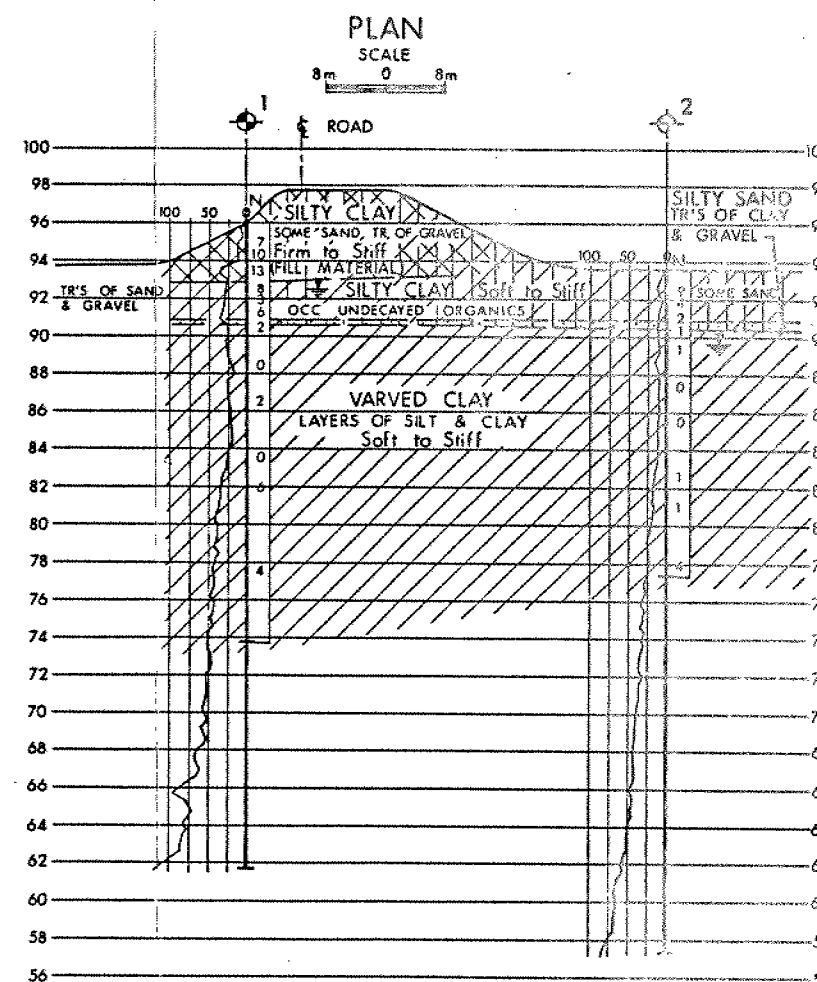
CONT No 70 No 14-70016	
WABI CREEK.	
CORE HOLE LOCATIONS & SOIL STRATA	



LEGEND			
	Bore Hole		
	Dynamic Cone Penetration Test (Cone)		
	Bore Hole & Cone		
N	Blows/0.3m (Std Pen Test, 475 J/blow)		
CONE	Blows/0.3m (60° Cone, 475 J/blow)		
	WL at time of investigation 86 08		

No	ELEVATION	STATION	OFFSET
1	96.1	0+94.0	2.5m Lt
2	93.6	0+101.4	18.0m Rt



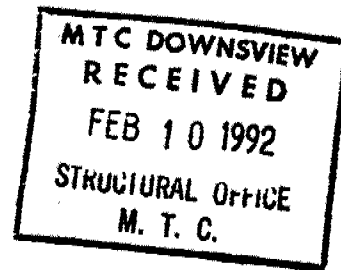
**NOTE**  
The boundaries between soil strata have been established only at Bore Hole locations. Between Bore Holes the boundaries are assumed from geological evidence.

NOTE: The complete foundation investigation and design report for this project and other related documents may be examined at the Engineering Materials Office, Downsview. Information contained in this report and related documents is specifically excluded in accordance with the conditions of Section 102-2 of Form 100.

REV	DATE	BY	DESCRIPTION

Geocres No 31M-51

HWY No	CONCESSION IV	HENWOOD	DIST 14
SUBMD PP	CHECKED	DATE	87 06 08
DRAWN DT	CHECKED	DATE	87 06 08
DWG			1470016-A



HILLCOAT BRIDGE

STRUCTURE SITE NO. 47-204

**MERLEX ENGINEERING LTD.,**  
Consulting Geotechnical Engineers



# MERLEX ENGINEERING LTD.

CONSULTING GEOTECHNICAL ENGINEERS

Reference No. 91/06/1061

December 23, 1991

H. Sutcliffe Ltd.  
9 Wellington Street  
P.O. Box 1208  
New Liskeard, Ontario  
POJ 1P0

Attention: Mr. I. M. ElAmin, P. Eng.

Re: Geotechnical Investigation  
Replacement of Hillcoat Bridge  
Township of Kerns  
MTO Site No.47-204

We have carried out a geotechnical investigation for the above project and we submit the results along with our comments and recommendations in this letter report.

## 1.0 FIELD WORK

The field work consisted of three boreholes and two dilatometer tests (DMT) at the locations shown on the enclosed Borehole Location Plan (Enclosure No. 2). This work was carried out in the period of June 17, 18 and 19, 1991, using a CME muskeg mounted drill rig with hollow stem augers.

Split spoon and thin walled tube samples were taken from the borehole using the standard penetration test method and, where cohesive material was encountered, in-situ vane shear strengths were carried out between samples. All boreholes were drilled and sampled to a depth of 16 m. The dilatometer tests were discontinued at depths of 20 m and 27.6 m.

The soil samples were brought to our laboratory where they will be stored for a period of three months following the date of this report and then discarded unless instructed otherwise.

The elevations of the ground level at the borehole locations were determined using a local geodetic benchmark (elevation 192.122 m) consisting of a nail and washer at the south side of a hydro pole located on the south side of the road, about 95 m east of the east end of the existing bridge.

## 2.0 SOIL CONDITIONS

The soil conditions at the borehole locations are shown on the enclosed Borehole Logs.

### 2.1 Fill

Boreholes 1 and 3 encountered about 2.1 m and 2.9 m of fill or probable fill at the west and east banks, respectively. The upper 0.6 m to 1 m of the fill consists of coarse granular material. The remainder consists mainly of sandy silt with a trace to some clay. The fill appears to be in a compact state in Borehole 1 and loose to compact in Borehole 3.

### 2.2 Fine Sand and Silt

The fill in Borehole 3 is underlain by what appears to be original topsoil, about 400 mm in thickness, consisting of black organic sand. This material and the fill in Borehole 1 are underlain by sandy silt

with a trace to some clay. In Borehole 2 this material occurs below about 1.4 m of silty fine sand. The sand and silt have a variable organic content. As sampled, the sand and sandy silt at Borehole 2 and 3 are generally in a loose to occasionally very loose state while the sandy silt in Borehole 1 is generally compact.

### 2.3 Varved Clay

The sandy silt extends to about elevation 184 in Borehole 1 and to about elevation 181 in Boreholes 2 and 3. A deposit of varved clay occurs below these elevations. As indicated by the boreholes and dilatometer tests these deposits extend to at least elevation 161 and probably considerably deeper based on local well records.

The clay in Borehole 1 has a crust extending to about elevation 181. In Borehole 2 and 3, the crust is absent and may have been removed by erosion in the past. The varved nature of the clay is only apparent below about elevation 177 where clay layers are typically between 25 mm and 50 mm in thickness and silt layers are typically of the order of 5 mm to 25 mm in thickness.

The natural moisture content was determined for each sample and the results are shown on the borehole logs which also show the result of atterberg limit tests on selected samples. The natural moisture content of the clay crust in Borehole 1 was of the order of 30%. Within the softer clay the natural moisture content of the clay layers is of the order of 50% to 70% while the natural moisture content of

the silt layers is typically of the order of 25%. The liquid limit of the lower clay is between 50% and 60% and the plasticity index is of the order of 35% to 40%.

The in-situ undrained shear strength of the clay was measured by vane tests in all boreholes and by dilatometer tests adjacent to Boreholes 1 and 2. The results of the field vane tests of all tests are plotted against elevation on Enclosure No. 1. The vane strengths shown on Enclosure No. 1 and on the borehole logs have been reduced by 20% on the basis of plasticity. The graph shows the desiccated crust in Borehole 1 with a shear strength up to about 46 kPa. Below the crust, the shear strength increases for a low value of about 14.5 kPa to a maximum of the order of 55 kPa at about elevation 161, which is the maximum depth reached by the dilatometer tests.

### 3.0 GROUNDWATER

At the time of the investigation the water level of the Wabi River at the bridge location was at elevation 182.0. In Borehole 1, groundwater reached elevation 185.2 as measured 43 hours after completion of the borehole. In Borehole 2 and 3, the groundwater level appeared to be considerably lower. In Borehole 2 it reached elevation 176.6 measured 66 hours after completion and in Borehole 3 it reached elevation 178.3 as measured 36 hours after completion of the borehole.

#### 4.0 DISCUSSION

The existing bridge is a three-span structure with timber piers and abutments supported on timber piles. The proposed new bridge will be of similar design with longer spans and with concrete piers and abutments on piled foundations. Current planning calls for raising the approach grade by about 1 m but it is possible that higher profile grades may be required.

##### 4.1 Piled Foundations

The soil conditions as determined at the borehole locations, confirm the choice of a piled foundation. Considering the extent of the soft clay stratum and experience with similar structures or similar soils, a system of timber friction piles is recommended.

The preliminary design drawings show the abutment and pier pile caps to be at about elevation 185 to 181, respectively. For design purposes, the piles are therefore considered to be bearing wholly in clay.

Using an average undrained shear strength of 24 kPa for the clay along the full length of the pile, the factored pile capacity ( $Q_p$ ) at ULS can be determined from the expression:

$$Q_f = 180 A_t + 12A_s L \text{ (kN)}$$

where,  $A_t$  = area of pile tip ( $m^2$ )

$A_s$  = average circumference of pile (m)

$L$  = length of pile (m)

For a size 36 timber pile with a butt diameter of 360 mm, a tip diameter 240 mm, an average shaft diameter of 300 mm and length of 14 m, the above expression produces a  $U_f$  equal to 164 kN.

For the same pile, neglecting all transient loadings, the pile capacity at SLS Type II ( $Q_s$ ) is considered to be of the order of 102 kN.

#### 4.2 Embankment

At the present time, it is proposed to raise the approach embankments by about 1 m. The proposed side and forward slopes are to be 3:1 and 3.3:1, respectively. It is understood that consideration is being given to raising more than 1 m, however, this has not yet been determined.

Numerous sections of the proposed construction have been reviewed and the critical section A-A, as shown on the enclosed plan, was chosen for detailed analysis using the STABL5 computer program.

Considering that the DMT data, which indicates the clay deposit is marginally overconsolidated, along with other published data on glacio-lacustrine deposits from this area (glacial lake Barlow-Ojibway) a total stress analysis (TSA) has been used in analyzing the slopes.



The computer printouts for the existing embankment and proposed, with 1 m of fill and a 3.3:1 side/forward slope are shown on Enclosure No. 3 in Appendix A. As can be seen the existing factor of safety is in the order of 1.25 and reduces to some 1.1 with the addition of 1 m of fill. As such, we recommend that at this time the depth of fill be limited to the 1 m depth and the fill slopes be maintained as shown on the preliminary Plan No. 90-587.

#### 4.3 Settlement

Using the result of the dilatometer tests and assuming a profile grade rise of 1.0 m, it is estimated that settlement resulting from the additional embankment fill will be of the order of 75 mm to 100 mm.

The comments in this report are intended for the guidance of the design engineer. The number of boreholes required to determine the localized conditions between boreholes directly affecting construction costs, equipment, scheduling, hydraulic elevator shafts, etc. would in fact be greater than what has been carried out for design purposes. Therefore, contractors bidding on this project or undertaking this work should make their own interpretations of the factual borehole results and carry out further work as they deem necessary to assess the scope of the project.

Reference No. 91/06/1061  
Date: December 23, 1991

-8-

We trust that the comments contained in this report are sufficient for your present requirements. However should you have any queries or if we could be of further assistance to you please do not hesitate to contact the undersigned.

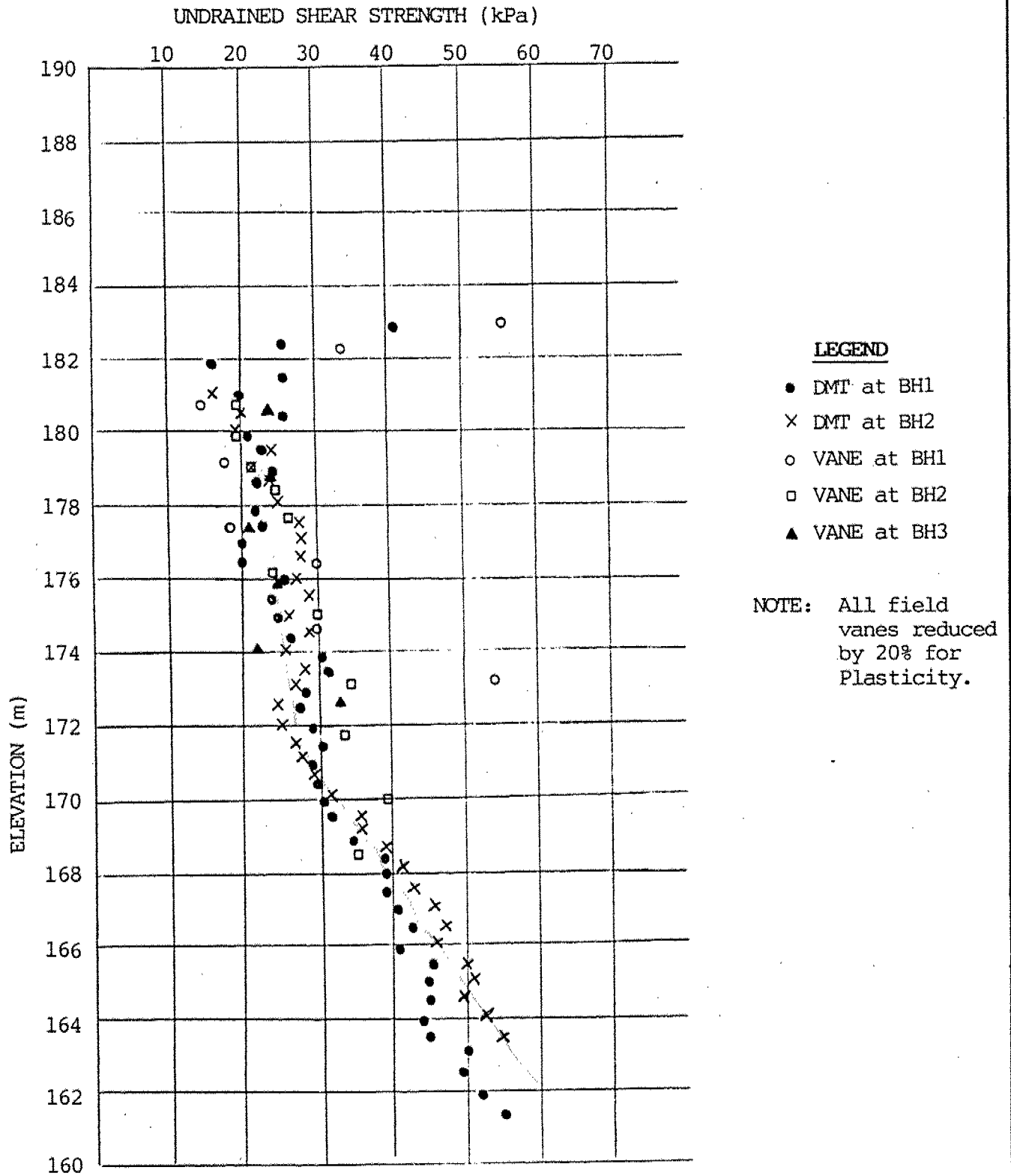
Yours very truly,

MERLEX ENGINEERING LTD.

A handwritten signature in dark ink, appearing to be 'M. A. Merleau', written in a cursive style.

M. A. Merleau, P. Eng.

APPENDIX "A"





JOB No.: 91/06/1061

LOCATION: Kern's Twp, Lot 2, Cons 3 &amp; 4

JOB DESCRIPTION: Soils Investigation, Hillcoat Bridge

METHOD OF BORING: CME 45

DATE: June 17, 1991

ELEV. DEPTH m	SOIL DESCRIPTION	SAMPLES			DEPTH SCALE SYMBOL m	PENETRATION RESISTANCE (blows/0.3m)				WATER LEVEL	
		No.	TYPE	"N"		SHEAR STRENGTH kPa					
						0	20	40	60	80	
						+	20	40	60	80	
188.86	Existing Grade										
187.86	FILL - 150 mm of organic sand over gravelly sand some silt with occasional cobbles, compact, brown	1	DO	10							
~1.00	PROBABLE FILL - sandy silt some clay, trace of fine gravel	2	DO	12	1						
186.76		3	DO	13	2						
~2.10	SANDY SILT - trace to some clay, compact, grey-brown to grey	4	DO	12	3						
		5	DO	15	4						
184.16		6	DO	3	5						
~4.70	VARVED CLAY - some sand seams, stiff to firm, grey-brown to brown and grey	6B	DO	6	6						
		7	DO	5	7						
180.96		8	DO	3	8						
7.90	VARVED CLAY - soft to firm, grey.										
180.79											
8.07											

DYNAMIC CONE PENETRATION TEST

SK=6.4

SK=4.2

WATER CONTENT (%)

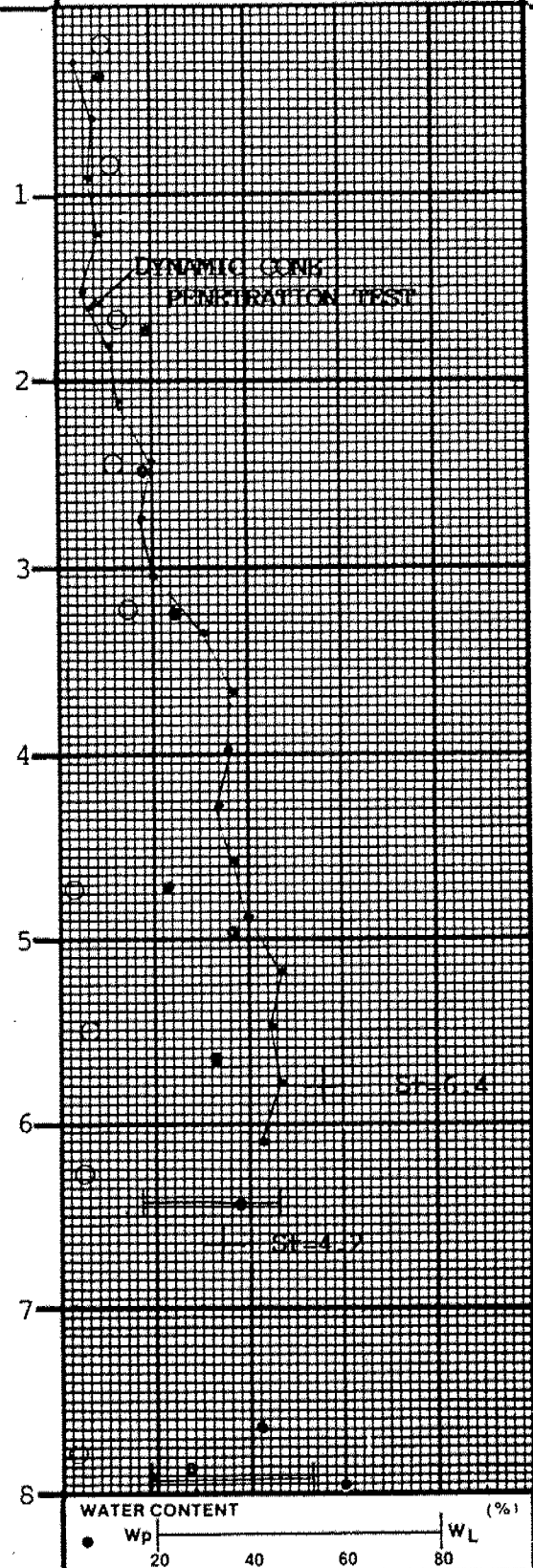
Wp WL

20 40 60 80

Water level at 3.65 m on June 19, after 43 hours.

Continued on page 2

Continued on page 2



Water level at 3.65 m on June 19, after 43 hours.

# LOG OF BOREHOLE No. 1 - Page 2 of 2



JOB No.: 91/06/1061

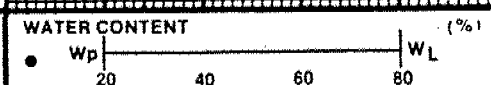
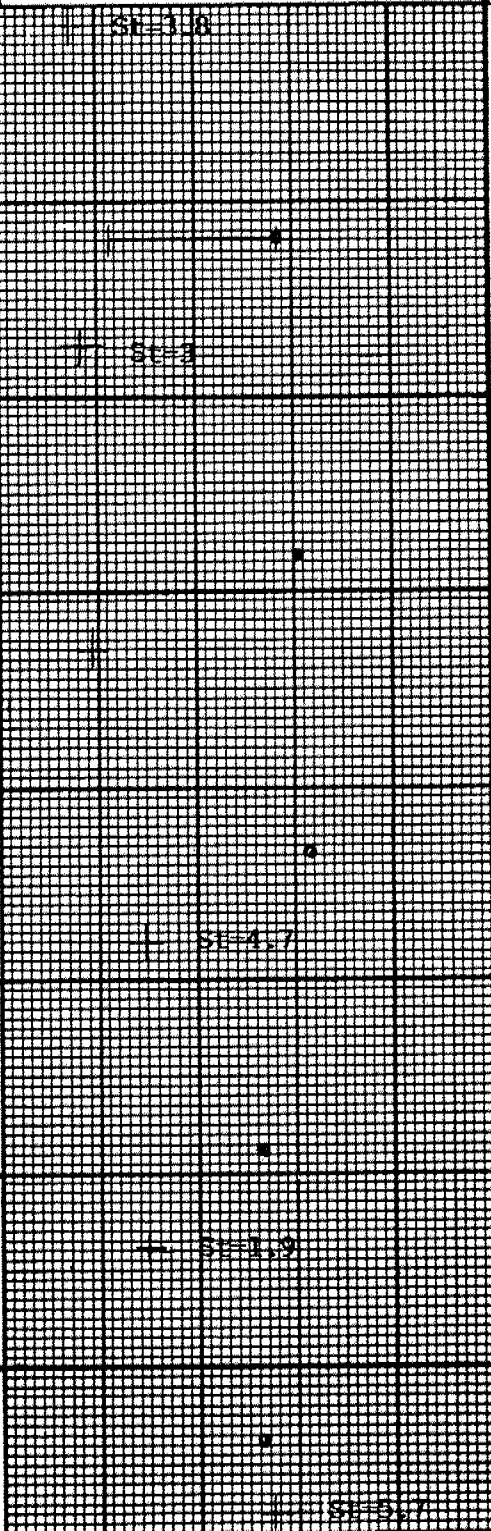
LOCATION: Kern's Twp., Lot 2, Cons 3 & 4

JOB DESCRIPTION: Soils Investigation, Hillcoat Bridge

METHOD OF BORING: CME 45

DATE: June 17, 1991

ELEV. DEPTH m	SOIL DESCRIPTION	SAMPLES			DEPTH SCALE SYMBOL m	PENETRATION RESISTANCE (blows/0.3m)				WATER LEVEL
		No.	TYPE	"N"		0	20	40	60	
180.79	Con't from page 1									
	VARVED CLAY - soft to firm, grey									
		9	DO	PM						
		10	DO	PM						
		11	DO	WR						
		12	DO	WR						
		13	DO	PH						
172.86										
16.00	END OF BOREHOLE									



# LOG OF BOREHOLE No. 2 - Page 2 of 2



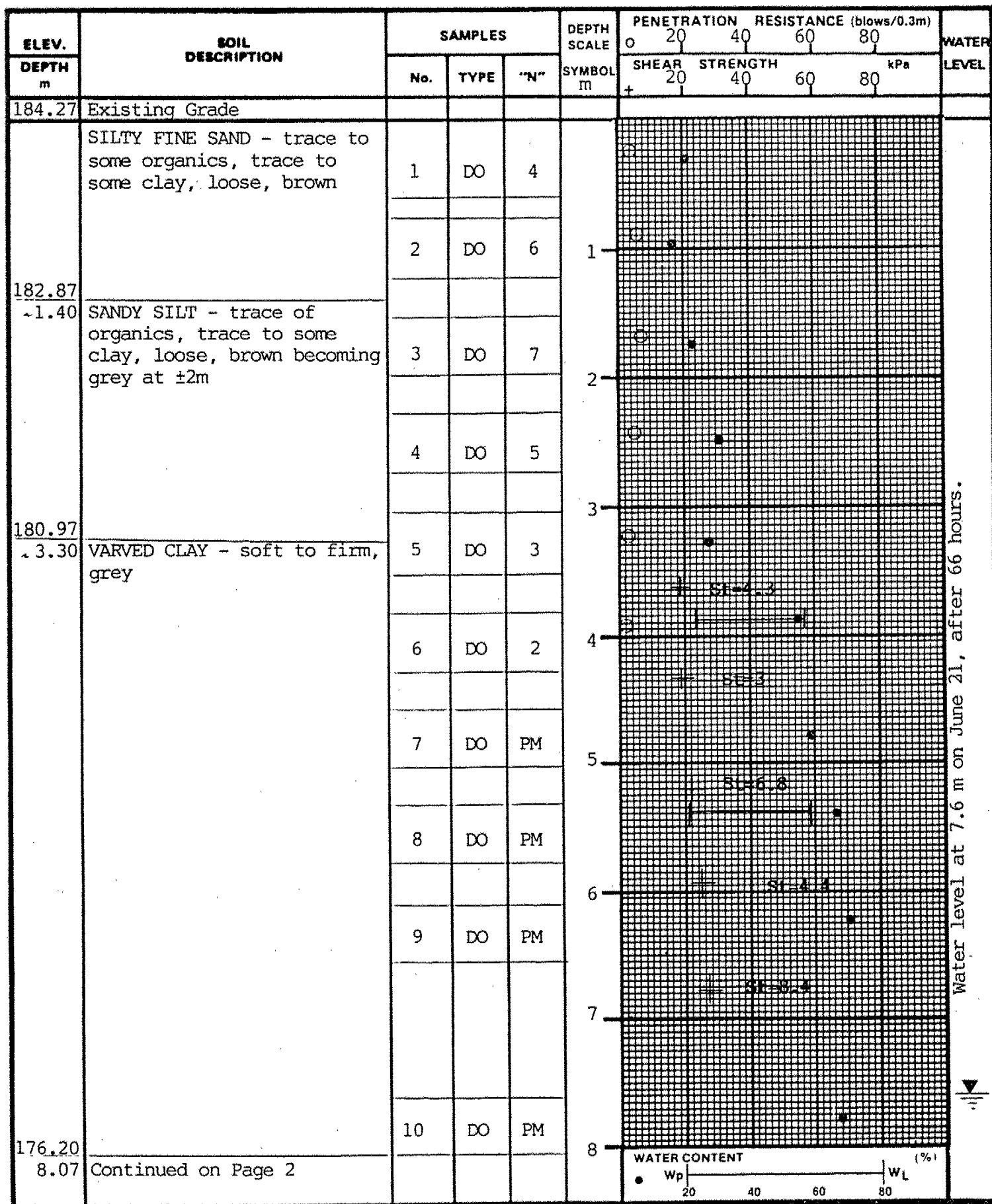
JOB No.: 91/06/1061

LOCATION: Kern's Twp, Lot 2, Cons 3 & 4

JOB DESCRIPTION: Soils Investigation, Hillcoat Bridge

METHOD OF BORING: CME 45

DATE: June 18, 1991



# LOG OF BOREHOLE No. 2 - Page 2 of 2



JOB No.: 91/06/1061

LOCATION: Kern's Twp., Lot 2, Cons 3 & 4

JOB DESCRIPTION: Soils Investigation, Hillcoat Bridge

METHOD OF BORING: CME 45

DATE: June 18, 1991

ELEV. DEPTH m	SOIL DESCRIPTION	SAMPLES			DEPTH SCALE SYMBOL m	PENETRATION RESISTANCE (blows/0.3m)				WATER LEVEL
		No.	TYPE	"N"		SHEAR + 20	STRENGTH 40	60	80 kPa	
176.20	Con't from page 1									
	VARVED CLAY - soft to firm, grey									
		11	DO	WR	9					
					10					
		12	DO	PM	11					
					12					
		13	DO	PM	13					
					14					
		14	DO	WR	14					
					15					
		15	DO	WR	15					
168.27					16					
16.00	END OF BOREHOLE									

WATER CONTENT (%)  
Wp 20 40 60 80 WL



# LOG OF BOREHOLE No. 3 - Page 1 of 2



JOB No.: 91/06/1061

LOCATION: Kern's Twp., Lot 2, Cons 3 & 4

JOB DESCRIPTION: Soils Investigation, Hillcoat Bridge

METHOD OF BORING: CME 45

DATE: June 19, 1991

ELEV. DEPTH m	SOIL DESCRIPTION	SAMPLES			DEPTH SCALE m	PENETRATION RESISTANCE (blows/0.3m)				WATER LEVEL
		No.	TYPE	"N"		SHEAR STRENGTH kPa	20	40	60	
188.53	Existing Grade									
	PROBABLE FILL - gravelly sand, brown changing at 0.6m to silt with fine sand and some clay, brown, loose to compact.	1	DO	14						
		2	DO	10	1					
		3	DO	7	2					
		4	DO	8						
185.63					3					
~2.90	BLACK ORGANIC SAND - possible original topsoil	5	DO	7						
185.23										
~3.30	SANDY SILT - trace to some clay, very loose to loose, brown	6	DO	3	4					
183.83		7	DO	4	5					
~4.70	SANDY SILT - with clay organic pockets throughout very loose to loose, grey	8	DO	7	6					
		9	DO	4	7					
181.53										
~7.00	VARVED CLAY - firm, grey	10	DO	PM	8					
180.46										
8.07	Continued on Page 2									

WATER CONTENT (%)  
Wp WL  
20 40 60 80

# LOG OF BOREHOLE No. 3 - Page 2 of 2



JOB No.: 91/06/1061

LOCATION: Kern's Twp., Lot 2, Cons 3 & 4

JOB DESCRIPTION: Soils Investigation, Hillcoat Bridge

METHOD OF BORING: CME 45

DATE: June 19, 1991

ELEV. DEPTH m	SOIL DESCRIPTION	SAMPLES			DEPTH SCALE SYMBOL m	PENETRATION RESISTANCE (blows/0.3m)				WATER LEVEL
		No.	TYPE	"N"		0	20	40	60	
180.46	Con't from Page 1									
	VARVED CLAY - firm, grey									
		11	TW	PM						
		12	TW	WR						
		13	DO	WR						
		14	TW	WR						
		15	DO	PM						
172.53										
16.00	END OF BOREHOLE									

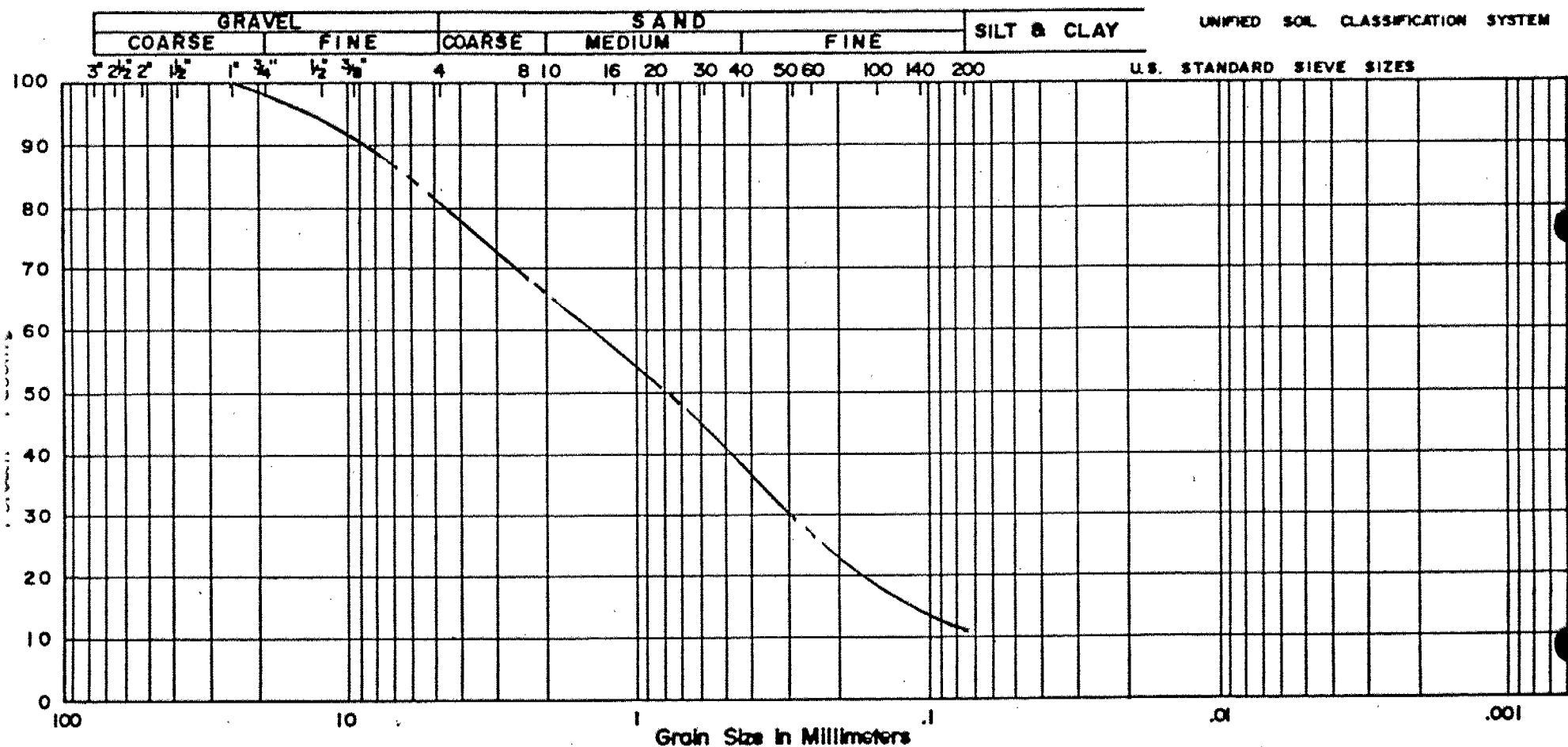
Water level at 10.2 m on June 21, after 36 hours.



91/06

OUR REFERENCE N<sup>o</sup> 1061

## GRAIN SIZE DISTRIBUTION



PROJECT: Hillcoat Bridge

LOCATION: Kerns Twp.

BOREHOLE N<sup>o</sup>: 1SAMPLE N<sup>o</sup>: 1

DEPTH: 0 - 0.6m

ELEVATION: 188.87 - 188.27

COEFFICIENT OF UNIFORMITY:  $D_{60}/D_{10} =$ COEFFICIENT OF CURVATURE:  $(D_{30})^2/D_{10} \times D_{60} =$ 

Classification of Sample and Group Symbol:

SAND WITH FINE GRAVEL, SOME SILT

## PLASTIC PROPERTIES

LIQUID LIMIT % =

PLASTIC LIMIT % =

PLASTICITY INDEX % =

MOISTURE CONTENT % =

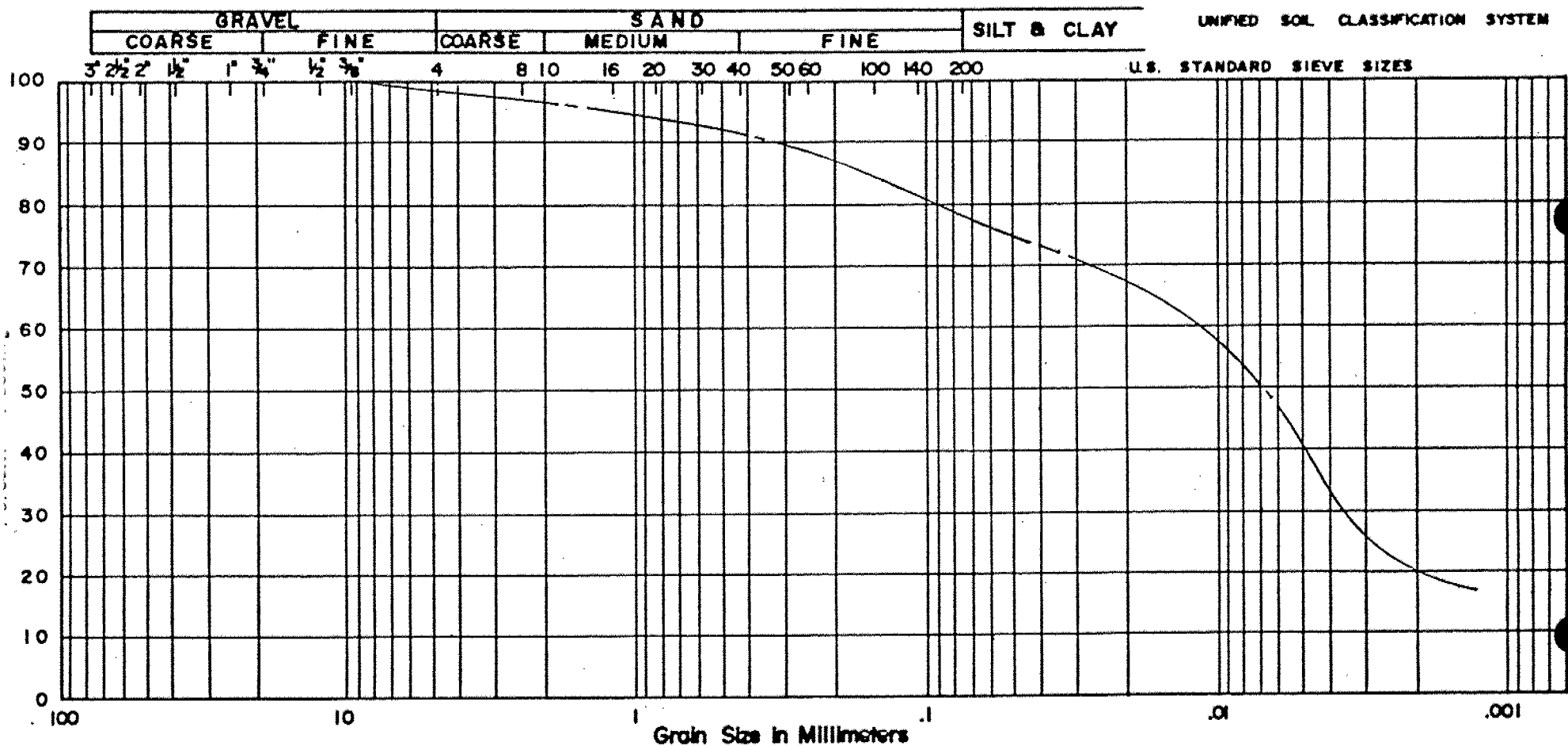
ENCLOSURE N<sup>o</sup> 1

MERLEX ENGINEERING LTD.

91/06/

OUR REFERENCE N<sup>o</sup> 1061

## GRAIN SIZE DISTRIBUTION



PROJECT: Hillcoat Bridge

LOCATION: Kerns Twp.

BOREHOLE N<sup>o</sup>: 1SAMPLE N<sup>o</sup>: 3

DEPTH: 1.5 - 2m

ELEVATION: 187.37 - 186.87m

COEFFICIENT OF UNIFORMITY:  $D_{60}/D_{10} =$ COEFFICIENT OF CURVATURE:  $(D_{30})^2/D_{10} \times D_{60} =$ **Classification of Sample and Group Symbol:**SANDY SILT, SOME CLAY, TRACE OF FINE  
GRAVEL

## PLASTIC PROPERTIES

LIQUID LIMIT	% =
PLASTIC LIMIT	% =
PLASTICITY INDEX	% =
MOISTURE CONTENT	% =

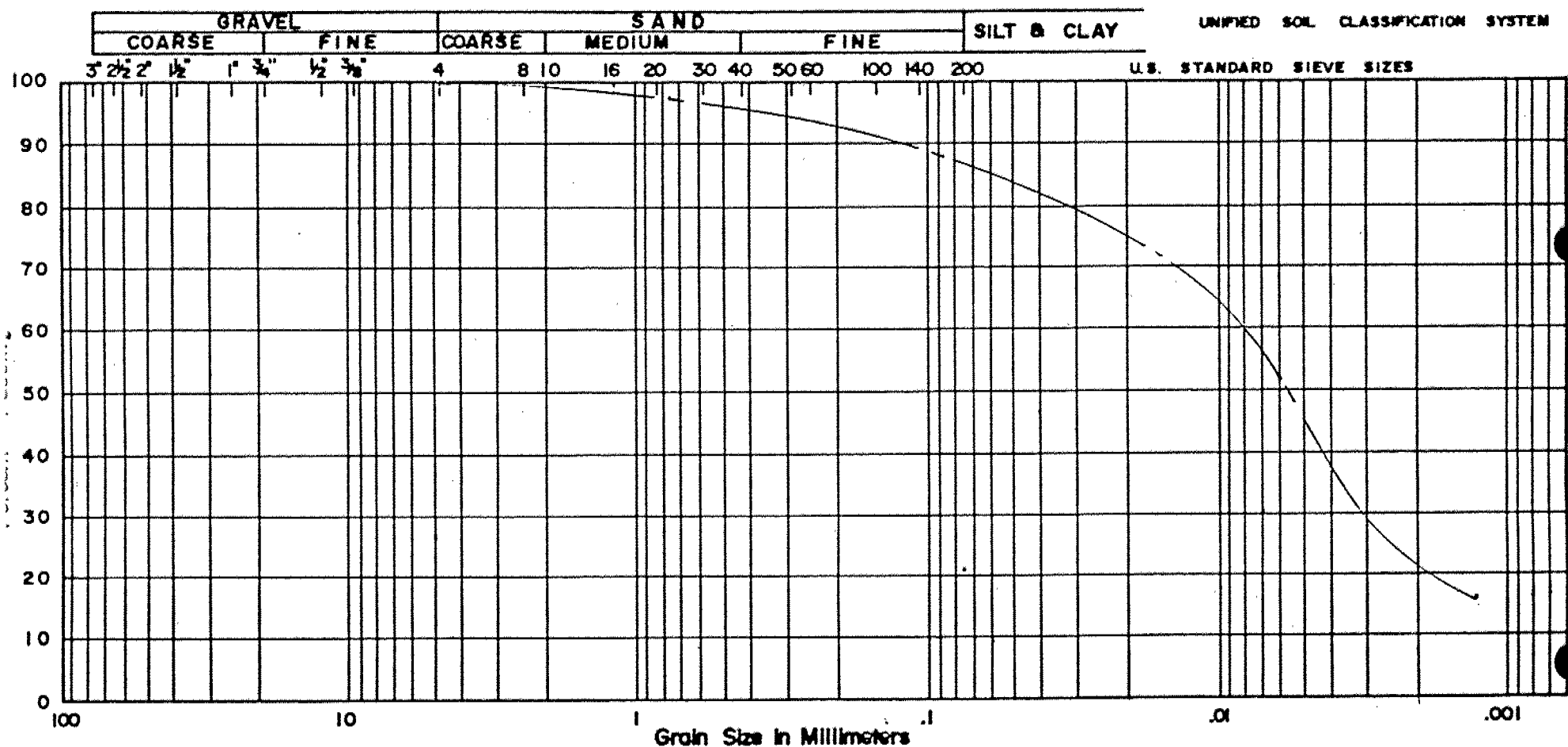
ENCLOSURE N<sup>o</sup> 1

91/06/

1061

OUR REFERENCE N°

## GRAIN SIZE DISTRIBUTION



PROJECT: Hillcoat Bridge

LOCATION: Kerns Twp.

BOREHOLE N°: 1

SAMPLE N°: 5

DEPTH: 3 - 3.5m

ELEVATION: 185.87 - 185.37m

COEFFICIENT OF UNIFORMITY:  $D_{60}/D_{10} =$ COEFFICIENT OF CURVATURE:  $(D_{30})^2/D_{10} \times D_{60} =$ 

Classification of Sample and Group Symbol:

SILT WITH CLAY, SOME SAND

## PLASTIC PROPERTIES

LIQUID LIMIT % =

PLASTIC LIMIT % =

PLASTICITY INDEX % =

MOISTURE CONTENT % =

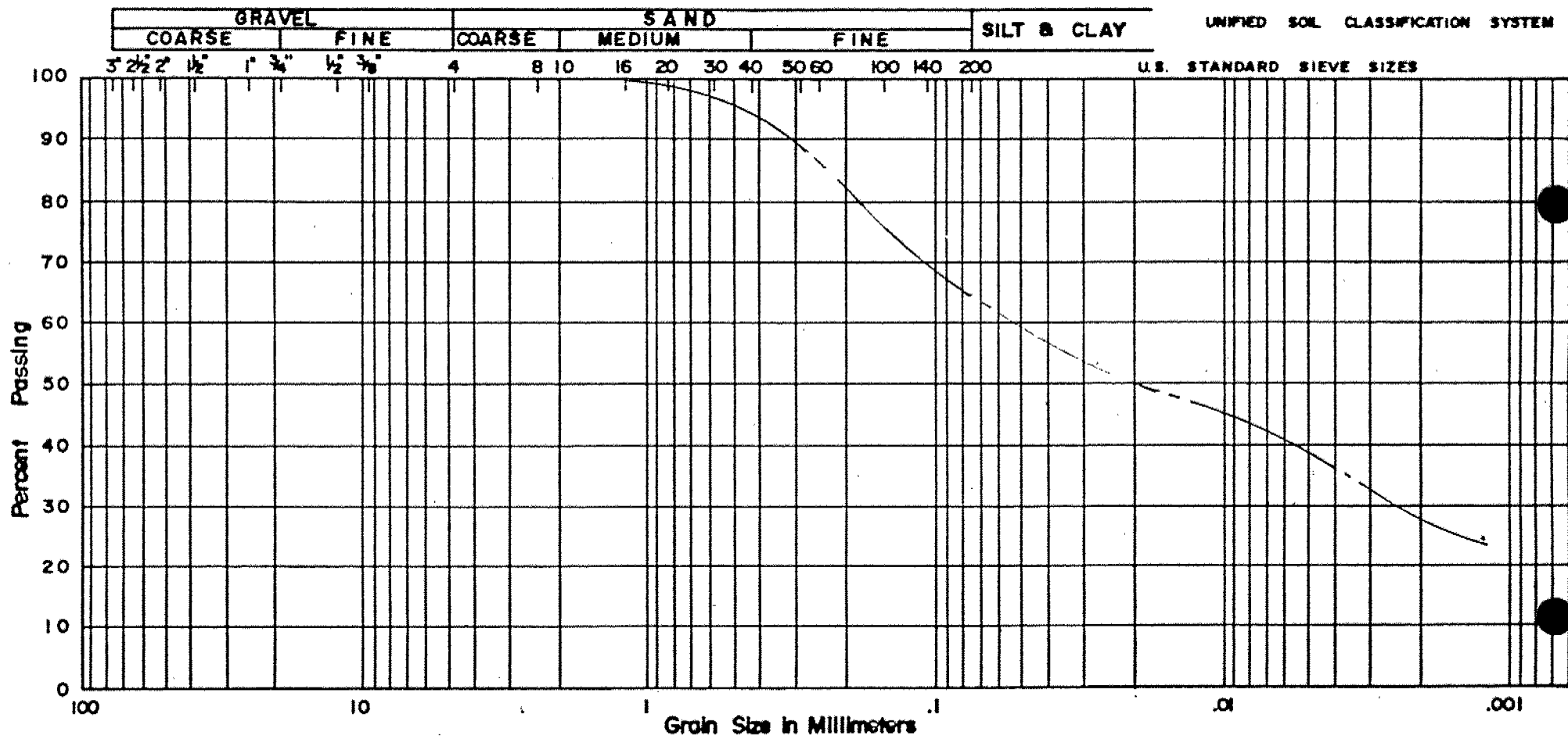
ENCLOSURE N°

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91/06

OUR REFERENCE N° 1061

## GRAIN SIZE DISTRIBUTION



PROJECT: Hillcoat Bridge

LOCATION: Kerns Twp.

BOREHOLE N°: 2

SAMPLE N°: 3

DEPTH: 1.5 - 2m

ELEVATION: 182.77 - 182.27m

COEFFICIENT OF UNIFORMITY:  $D_{60}/D_{10} =$ COEFFICIENT OF CURVATURE:  $(D_{30})^2/D_{10} \times D_{60} =$ 

## PLASTIC PROPERTIES

LIQUID LIMIT % =

PLASTIC LIMIT % =

PLASTICITY INDEX % =

MOISTURE CONTENT % =

Classification of Sample and Group Symbol:

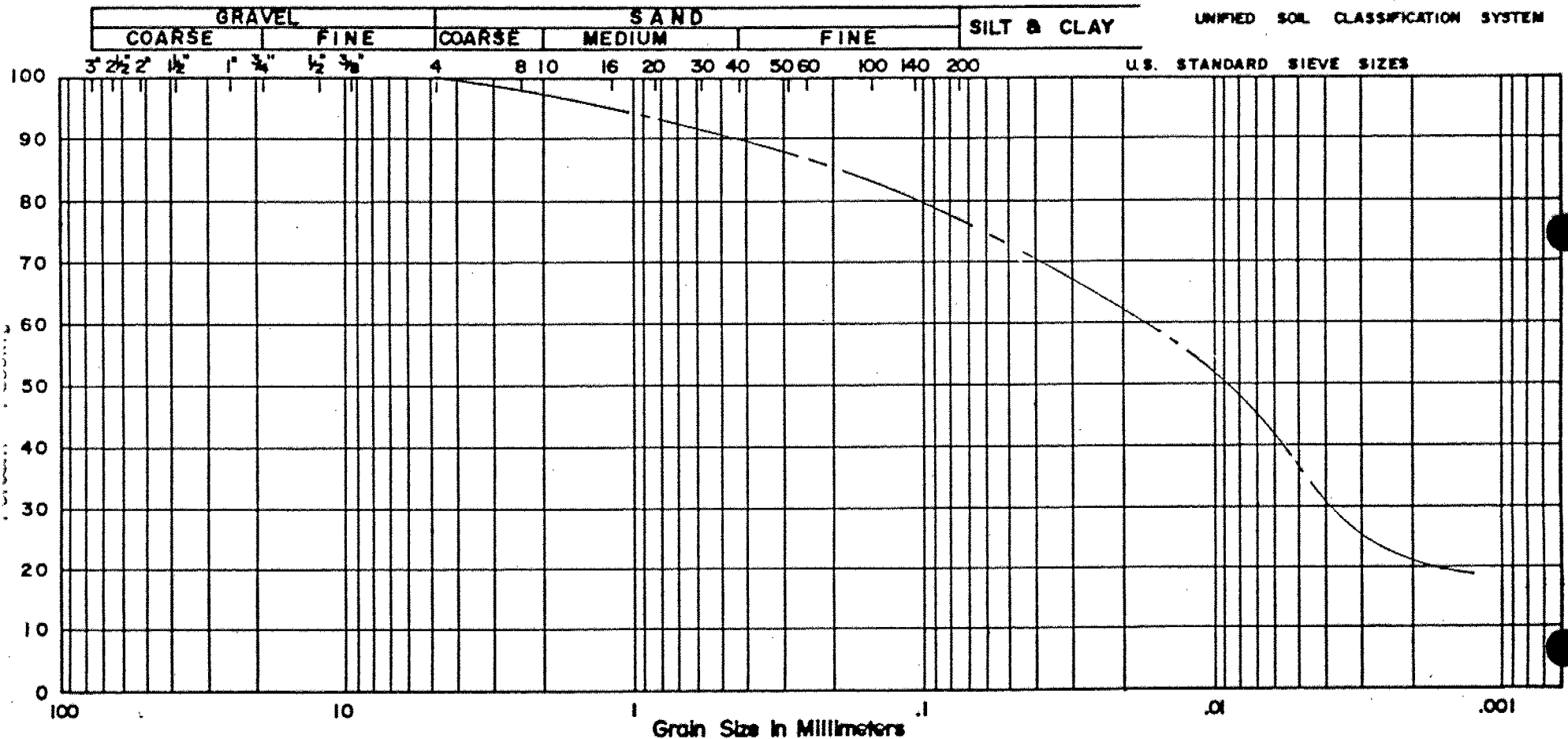
SANDY SILT WITH CLAY

ENCLOSURE N°

91/06/

OUR REFERENCE N° 1061

## GRAIN SIZE DISTRIBUTION



PROJECT: Hillcoat Bridge

LOCATION: Kerns Twp.

BOREHOLE N°: 3

SAMPLE N°: 3

DEPTH: 1.5 - 2m

ELEVATION: 187.03 - 186.53m

COEFFICIENT OF UNIFORMITY:  $D_{60}/D_{10} =$ COEFFICIENT OF CURVATURE:  $(D_{30})^2/D_{10} \times D_{60} =$ 

Classification of Sample and Group Symbol:

SILT WITH FINE SAND, SOME CLAY

## PLASTIC PROPERTIES

LIQUID LIMIT % =

PLASTIC LIMIT % =

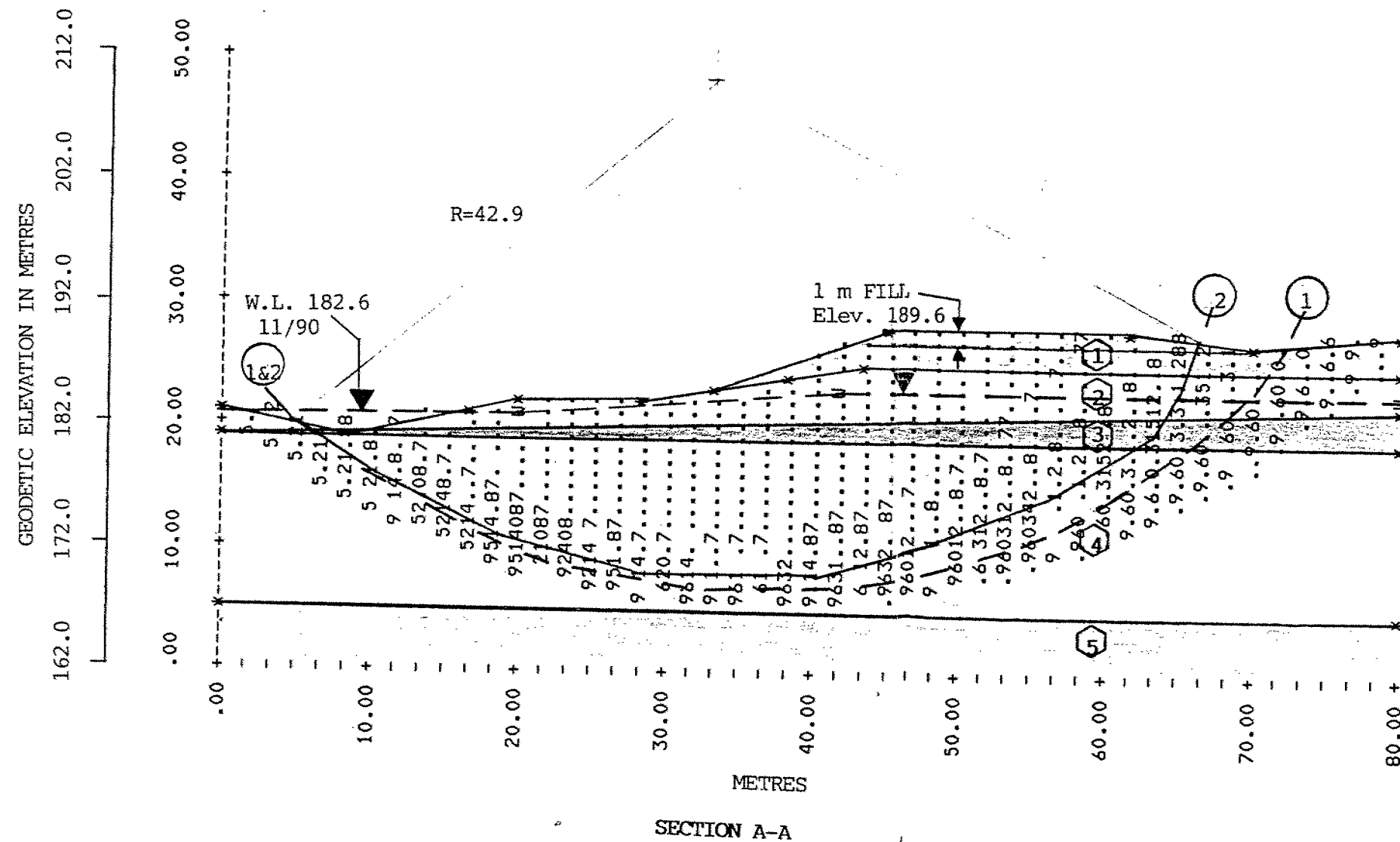
PLASTICITY INDEX % =

MOISTURE CONTENT % =

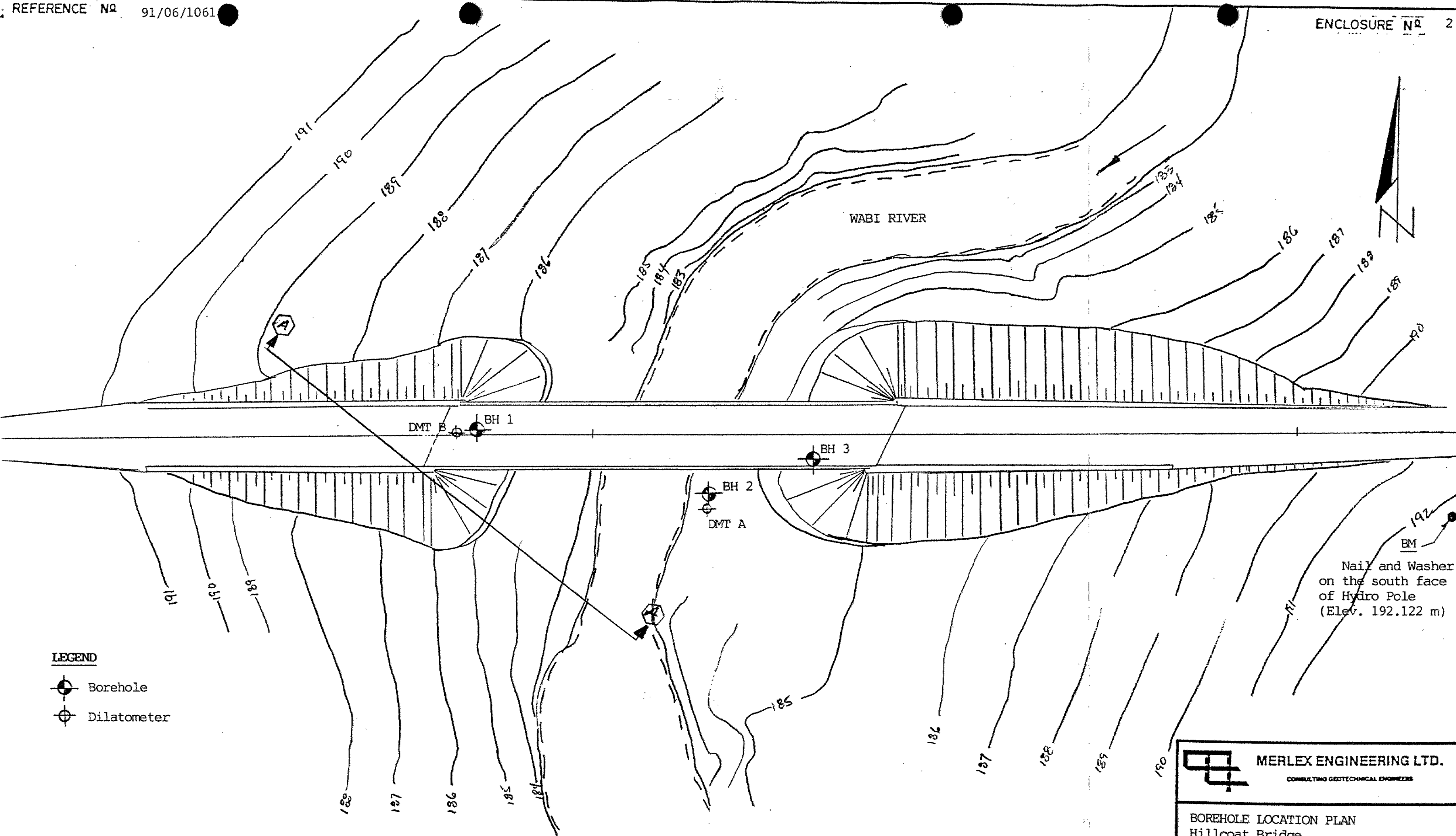
ENCLOSURE N°

MERLEX ENGINEERING LTD.

SOIL PARAMETERS					SUMMARY OF SAFETY FACTORS			
SOIL DESCRIPTION	MARK	UNIT WEIGHT		SHEAR STRENGTH		FAILURE SURFACE	CONDITION	Fs
		NAT. MC.	SAT	COHESION	PHI			
Granular Fill	①	1850	1920	0	40	CIRCLE ①	Existing Embankment	1.25
Sandy Silt	②	1745	1790	0	30	CIRCLE ②	1 m Fill	1.06
Firm Clay (Crust)	③	1800	1800	4600	0			
Soft Clay	④	1760	1760	2250	0			
Firm Clay	⑤	1820	1880	3375	0			
		kg/cu.m.		kg/sq.m.				







**MERLEX ENGINEERING LTD.**  
CONSULTING GEOTECHNICAL ENGINEERS

BOREHOLE LOCATION PLAN  
Hillcoat Bridge  
MTO Site 47-204  
Township of Kerns  
New Liskeard, Ontario

SCALE: N.T.S.